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GENTLEMEN EMINENT IN SCIENCE AND LITERATURE.

THE

FIRST AMERICAN EDITION,

Corrected and improved by the addition of numerous articles relative to

THE INSTITUTIONS OF THE AMERICAN CONTINENT,

ITS GEOGRAPHY, BIOGRAPHY, CIVIL AND NATIONAL HISTORY, AND TO VARIOUS DISCOVERIES IN

SCIENCE AND THE ARTS.

IN EIGHTEEN VOLUMES.

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THE AMERICAN EDITION

OF THE NEW

EDINBURGH ENCYCLOPÆDIA.

LEIBNITZ.

LEIBNITZ, Godfrey William, a celebrated philosopher and mathematician, was born at Leipsic in 1646, and was the son of Frederic Leibnitz, professor of moral phliosophy, and secretary to the university in that city. He made a rapid progress in classical learning, and discovered, in his youth, a ready talent of versification. His academical studies were very extensive, but were particularly directed to the writings of the Greek philosophers, whose systems he attempted to reconcile with each other, and with that of Des Cartes. He devoted himself chiefly, however, to the study of the law, as a professional pursuit; and was admitted bachelor of that faculty at Jena in 1665, and doctor at Altorf in the year following. Upon a visit to the university of Nuremberg, he connected himself with a society of learned men, who were engaged in the pursuit of the philosophers stone, and to whom he acted for some time in the office of secretary; he having attracted the notice of Baron Boinebourg, first minister of the Elector of Mentz, he repaired under his patronage to Frankfort on the Maine. In 1668, he wrote a treatise in support of the elector palatine's pretensions to the crown of Poland, which had then become vacant, and was in consequence invited to the court of that prince; but his patron Boinebourg prevented his acceptance of the invitation, by procuring him the office of counsellor of the chamber of review at Mentz, and afterwards engaged him to take charge of his son at Paris. He applied himself in that city to the study of mathematics, in which he had not previously made much progress, particularly to the writings of Pascal, St. Vincent, Huygens, &c.; and attracted so much notice by his invention of a new arithmetical machine, that he was offered a seat, as a pensionary member, in the Academy of Sciences. But his promotion in France would have required his desertion of the principles of Protestantism; and removing to England in 1673, he became acquainted with the learned members of the Royal Society, and especially with Mr. Collins, from whom he received some hints of the method of fluxions, which had been invented by Sir Isaac Newton in 1664 or 1665. Receiving advice of the death of the Elector of Mentz, by which he lost his office and salary, he returned to France, and was soon afterwards appointed by the Duke of Brunswick-Lunenburg one of his counsellors, but permitted to remain at Paris in order to complete his arithmetical machine. In 1676 he returned to England, and went from thence to Hanover, where he experienced the same favour from Ernest Augustus, bishop of Osnaburg (afterwards Geo. I.) as from his predecessor, and at his request began to compile a history of the house of Brunswick. In 1700, he was admitted a member of the Royal Academy of Sciences at Paris; and in the same year was appointed perpetual president of the Academy at Berlin, which the elector of Brandenburg (afterwards king of Prussia) had founded by his advice. To this institution he sent numerous dissertations on various subjects; and projected an academy of the same kind at Dresden, but which the troubles in Poland prevented from taking effect. About this time he applied himself to the construction of "a universal language," which had already occupied the attention of the learned, and which he proposed to accomplish by employing characters resembling as much as possible those of algebra. His fame spread rapidly over Europe, and attracted the patronage of several crowned heads. In 1711, he was made aulic counsellor to the emperor, from whom he received a pension of 2000 florins, and who promised to double the sum, upon condition of his residing at Vienna. He was chosen as a privy counsellor also by the czar of Muscovy, with a pension of 1000 ducats; and it is said, that he was offered the place of keeper of the Vatican Library at Rome, by

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Cardinal Casanata. Upon the accession of his patron the elector of Hanover to the throne of Great Britain, Leibnitz again visited England in 1714, where he was treated with great distinction; and, soon after his arrival, he engaged in a controversy with Dr. Samuel Clarke, on the subjects of free-will, space, &c. which terminated only with his death in 1716, at 70 years of age.

Leibnitz, as to his person, was of a middle stature and spare habit of body; near-sighted, of a studious air, and mild aspect. He was extremely temperate in his mode of living; taking his meals only when hunger impelled him, and using a plain though strong diet. His temper was naturally hot, but he was able to restrain it, after the first hasty emotions were over, and was both affable and polite in conversation, as well as greatly averse to disputation. He was indefatigable in his application to study; and used to impress any subject indelibly on his memory by merely committing it to paper. He was perpetually occupied with projects, chiefly for the promotion of learning and science; but one of his most romantic schemes was that of a general government for Europe under one power, in which the emperor of Germany was intended to direct the civil, and the pope the ecclesiastical department. He was seldom neglectful of his own interest, in the midst of all his speculations, and was sufficiently solicitous to secure the favour of princes, as well as to turn their patronage to his own advantage. He was indeed considered as fond of accumulating money, of which he left at his death about 60,000 crowns; and the greater part of the sum was found in sacks, in various kinds of specie. In his religious sentiments, he professed to be a Lutheran, and wrote several treatises against heretical atheistical tenets; but his scheme of setting the pope at the head of the religion of Europe—his neglect of all public worship—and the sentiments expressed in several of his writings, have made it probable that he had no very fixed opinions on the subject, and that he concealed those which he really entertained. He was never married, though he made some proposals with that view, when he was about 50 years of age; but the lady desiring time to consider, gave him an opportunity to do the same; and led him to the conclusion that "marriage was a good thing, but that a wise man ought to consider of it all his life." He was unquestionably a man of eminent genius and extensive learning. His writings treat of a vast variety of subjects, scientific, literary, political, and metaphysical, and were published in different forms and places; but were collected by M. Dutens, and printed at Geneva in six large vols. 4to, in 1768. A very full account of the dispute between Leibnitz and Newton, respecting the invention of fluxions, will be found under FLUXIONS. See also MATHEMATICS, *History of.* (*q*)

LEICESTER, the county town of Leicestershire, is situated in the hundred of Goscote. It is 98 miles to the north of London. It stands on the river Soare. The houses are principally ranged in three parallel streets, intersected by several smaller ones. They are in general not so modern as are principally found in manufacturing towns. There are five parish churches, the most celebrated of which is St. Margaret's; but St. Nicholas' church is esteemed the most ancient. The floors of all, or nearly all, the churches in this town, are considerably lower than the level of the church-yards and the streets, whence it is supposed, that the latter must have gradually been raised since the building of the former. The county jail, which was built in the year 1791, is on the plan of Mr. Howard. The town jail was built about the same period. At the southern extremity of the town is the infirmary, a square building with two wings, calculated to accommodate 54 patients, exclusive of the fever ward; near it is an asylum for indigent lunatics. The exchange stands in the middle of the market-place. There is also a theatre in Leicester, and it is noted for the number and excellence of its inns. To the south-east of the town is the new walk, 3-4ths of a mile long, and 20 feet wide; from it there are many pleasing views of the town, meadows, and surrounding country. Leicester has returned two members to Parliament ever since the reign of Edward I. In the reign of Henry VIII. one was chosen by the mayor and his brethren, and the other by the inhabitants at large. This mode of election continued till the time of Charles II. when the commons at large returned both members. From this period, the right of election has been vested in the freemen not receiving alms, and in the inhabitants paying scot and lot. The number of voters is supposed to be about 2000; but persons living in the borough by certificate, not having gained a settlement by renting 10*l.* per annum, or serving in an annual office, are not entitled to vote. The government of the town is vested in a mayor, recorder, steward, bailiff, 24 aldermen, 48 common councilmen, town-clerk, &c. The chief trade of Leicester consists in combing and spinning wool, and manufacturing it into stockings. The goods are chiefly coarse; part are consumed in the county, and part exported. The trade of Leicester was long stationary, but latterly it has been much improved and extended. In the year 1680, there was only one stocking-maker in this town; at present there are nearly 100, who employ about 4000 frames; and, when trade is good, between 15,000 and 20,000 dozen pairs of stockings are manufactured in a week. Between 7000 and 8000 persons are directly or indirectly in some branch of the hosiery business in this town. In the year 1801, there were 3990 houses, and 16,953 inhabitants.

By the population returns in 1811, it appears there were 4682 houses and 23,146 inhabitants. See *Beauties of England and Wales*, vol. ix; and Pitt's *Agricultural Survey of Leicestershire.* (W. S.)

LEICESTERSHIRE is an inland county, situated nearly in the centre of England: It is bounded on the north by Nottinghamshire and Derbyshire, from which it is divided, in some parts, by the rivers Trent and Soare; on the west it is bounded by Derbyshire and Warwickshire, from the latter of which it is divided by the small river Ankor and the Roman road called Watling Street; on the south it is bounded by Northamptonshire, from which it is divided by the rivers Welland and Avon; and on the east it is bounded by Rutlandshire and Lincolnshire. With respect to its shape, it has been compared to a "shoulder of mutton with the shank cut off." Its greatest length is from the south of Lutterworth to the northern part of the vale of Belvoir; on this line it measures about 45 miles: its general breadth, from east to west, is rather more than 40 miles; its mean diameter is about 30 miles; the circumference is about 150; and its superficial contents have been variously estimated, as high as 560,000 acres, and as low as 522,240. According to the latter estimate, Leicestershire appears to be the 26th county in England with respect to size.

It is divided into six hundreds, viz. Framland, Gartree, Goscote East and West, Guthlaxton, and Sparkenhoe. There are eleven market towns, of which the principal are Leicester (the county town), Loughborough, Hinchley, Lutterworth, Melton Moubray, Market Harborough, Market Bosworth, and Ashley-de-la-Zouch. There are in this county 192 parishes; but the number of places which pay separate parochial rates is 323. It sends only four members to parliament; two for the county and two for Leicester. It is in the province of Canterbury, and diocese of Lincoln: The whole county is under one archdeacon, and it contains six deaneries. It is in the midland circuit.

The principal rivers in Leicestershire are, the Soare, the Swift, the Welland, the Avon, the Wreke, and the Ankor; but they are all very small streams. The Soare rises in the south-west border of the county, whence it flows to Leicester. Soon afterwards it is joined by the Wreke from the north-east; its course then bends to Mount Sorrel and Loughborough, till it falls into the Trent. It is made navigable for barges from its junction with the Trent to several miles above Leicester, a distance of upwards of 20 miles. The Swift rises in this county, flows by Lutterworth, and then enters Warwickshire. The course of the Welland in this county is also for a short space; it rises in it near Harborough, and soon afterwards enters Northamptonshire. The Avon rises nearly in the same part of the county; but its course is directly opposite to that of the Welland, being through Warwickshire into the Severn. The course of the Wreke has been already mentioned. The Ankor rises near the source of the Soare, and running in a north-west direction near the borders of Warwickshire, falls into the Avon. Hence it appears, that the Soare, and its tributary streams, the Wreke and the Welland, flow into the east sea, while the other rivers of this county flow into the west sea.

There are several artificial navigations in this county; that of the Soare, or the Leicester Navigation as it is called, has already been briefly noticed. Besides the main stream, or cut, on or near the line of the river Soare, down the Soare valley to the Trent, there is a collateral branch to Loughborough, which is continued over part of Charnwood forest by canal, or rail-way, to the collieries and lime-works in that part of the county. By means of the Leicester and Melton-Moubray canal, the rivers Wreke and Eye form a communication with the Soare; and the former rivers, by means of cuts, &c. are made navigable to Melton-Moubray, where the Oakham canal commences. This canal runs a course of 15 miles, about half of which is in Leicestershire, the rest in Rutlandshire; in the first $8\frac{1}{2}$ miles it has a rise of 126 feet, afterwards it is level. The Grantham canal merely skirts the east side of the county, on the borders of Nottinghamshire, running through the vale of Belvoir, to which it is of great advantage, the roads being there almost impassable during winter. The Union canal begins at and joins the Soare navigation at Leicester. Its course for three miles is nearly parallel to that river; it then passes towards Wigston, &c. and on to Northampton, into the river New Navigation and Grand Junction canal. Its whole course, from Leicester to Northampton, is $43\frac{3}{5}$ miles, with 407 feet 6 inches lockage; the rise is 110 feet, and the fall 197 feet 6 inches. It passes through 4 tunnels. There is a cut to Market Harborough. In its course it crosses the river Welland. The Ashby-de-la-Zouch canal joins the Coventry canal near Nuneaten. It soon afterwards enters Leicestershire near Hinckley, and passing Market Bosworth, proceeds to Ashby-de-la-Zouch. It is 50 miles long, with 250 feet lockage. It was intended to have been continued to the navigable part of the Trent, below Barton. There are several rail-ways, as appendages to this canal, to the collieries and lime-works in this part of the county.

The climate of Leicestershire is, on the whole, mild, and very salubrious; and the harvest, especially in the western parts of the county, at least ten days earlier than it is in the counties on the east coast of England. The average annual fall of rain is supposed to be about 30 inches.

Leicestershire is one of the few counties in England which is equally celebrated for its agriculture and its manufactures. Some of the estates in it are very large, particularly that of the Duke of Rutland. The tenures are principally freehold. There is little copy-hold, and still less holding church tenure. In the grazing districts of this county, there are many substantial yeomen who farm their own estates: In those districts the farms are large; in the other parts they seldom exceed 200 acres. The graziers have long been justly celebrated for their skill, experience, intelligence, capital, and success; and there are many of them by no means inferior, in most of these respects, to the well-known Bakewell.

Leicestershire is much more distinguished as a grazing than as an arable county; and the tillage land is much less, in proportion, than that of most other counties. In the south, east, and middle of the county, are many farms without any tillage land whatever. In the north and west a proportion of each farm is generally kept in tillage. According to Mr. Pitt, in his Agricultural Survey, one-half of the strong clay loam (the whole of which he estimates at 160,000 acres) is in occasional tillage: the whole of the more friable loam, which he also estimates at 160,000 acres, is in occasional tillage. According to this estimate, there are 240,000 acres in occasional tillage, or under the convertible husbandry: Of these, he reckons 25,000 acres under wheat; 40,000 under barley; 30,000 under oats; 15,000 under beans, peas, and vetches; 40,000 under turnips, cabbages, &c.; 85,000 under clover; and 5000 clean fallow. In the mode of cultivating these crops there are few things requiring particular notice. The wheat harvest is in August and the beginning of September; the average produce of the county is about 28 bushels. Barley is a favourite crop, and is generally sown after some green crop; the produce is large, about $4\frac{1}{2}$ quarters per acre. Leicestershire was formerly famous for beans; and, indeed, the greater part of its soil is particularly well suited for this crop. From the large quantities and excellent quality of this crop of grain near Barton, this village obtained the name of Barton in the Beans. At present, however, beans are not much cultivated. Turnips are extensively sown, and their culture is pretty well understood. Cabbages are more grown in Leicestershire than in most other counties, the soil particularly suiting them: They are generally planted in drills: they are given with great advantage to ewes and lambs in spring. The natural meadows on the banks of the Leicestershire rivers are not only extensive, but for the most part of good quality; especially those on the banks of the Soare, near Leicester, and, indeed, as far as its junction with the Trent. The oldest feeding land is in the south and east of the county. These pastures consist principally of grasses, there being little even of white clover. There is very little old wood in the county, and, indeed, it is by no means a woodland county; though in many parts there is a great deal of hoop raw timber

As the spirit of improvement in Leicestershire has been chiefly directed to grazing, great attention has been paid to draining the land; and Mr. Elkington's method was very early adopted in this county. Irrigation has also been carried on with considerable spirit and success.

It is from its cattle and sheep, however, particularly the latter, that Leicestershire derives its fame as an agricultural district; and for this fame it is indebted to the late Mr. Bakewell of Dishley Farm, near Loughborough. Before he began his improvements, this county possessed no peculiar breed of cattle; at least it was by no means celebrated for a good breed. It is foreign to the object of this article to trace the means by which he brought the Leicester cattle and sheep to their present high character and perfection; but we may mention generally the results of his improvements. "The present improved breed of cattle is finer boned, finer in the neck, throat, and bosom; the back straight, wide, and loaded with flesh; the rump wide, thick, and fleshy on the points, insomuch that, in some individuals, hillocks of fat are found thereon, and about the root of the tail." The colour is red, the legs short, with thin, wide, and spreading horns. The weight, when fat, from nine to ten score the quarter, but often much more. The principal aim of the graziers, is to fatten their cattle for the butcher; but attention is also paid, in some parts of the county, to the dairy. Near Hinckley, Bosworth, &c. are many large dairies; and also on the borders of Derbyshire, on the banks of the Trent, and in the vale of Belvoir. The exquisite cheese known by the name of Stilton, is made in Leicestershire. A good deal of this kind of cheese is made on the farms near Melton-Moubray. The quantity of cheese generally sent to Leicester October fair, is about 200 tons annually; and it is calculated, that of the 5000 tons annually sent down the Trent, from Leicester, Nottingham, Derby, and the north of Staffordshire, Leicester produces at least 1500 tons, which, it is calculated, will require 7500 dairy cows. There are three kinds of sheep at present kept in Leicestershire; the old Leicester, the new Leicester, and the forest sheep. The old Leicester seem to have been a cross between the Leicestershire and the old stock of the county: They are large, heavy, and full of wool; but large boned, their wool coarse, and they take a long time to fatten. This breed, however, is gradually approaching to the second kind, or the new Leicester. For this latter, the county, as has been remarked, is indebted to Mr. Bakewell. "Their offals are small, and their profitable points are large; their backs are broad and straight; their breasts are full, bellies tucked up, heads small, necks short, legs thin, pelts light, and wool fine of its kind; they are quiet in temper and disposition, and capable of being fattened in a short time, on a small proportion of food, and to a great weight, in proportion to their apparent size." Mr. Bakewell has fattened mutton to six inches thick of fat upon the ribs. Fat weathers will weigh about 25lb. a quarter; the average fleece about 7lb. The weight of the bones is proportionally very trifling: On a shoulder of 19lb. the bones frequently will not weigh more than six ounces. The forest sheep are principally confined to Charnwood: they are white or grey-faced, with legs of the same colour as the face; generally without horns, and with coarse wool.

Mr. Bakewell paid attention to the improvement of the breed of horses, as well as of cattle and sheep; but long before his time, Leicestershire was famous for a useful and beautiful breed of strong black horses. It is still a horse-breeding county, not only for the plough, waggons, &c. but also for the race-course and the chase. The fairs of Ashby, Loughborough, Harborough, Burton-on-Trent, Rugby, Ashburn, Stafford, &c. are principally supplied with Leicestershire horses, which are here bought up for the drays of London, &c. Mules have long been used in this county, both for draught and the saddle; they have also been used in the plough. The swine of Leicestershire, having partaken of the improvement of Mr. Bakewell, are of a better breed than are to be met with in most other counties.

The principal manufactures of Leicestershire are intimately connected with its great product of wool. They consist of wool-combing, woollen yarn, worsted, and stockings principally or wholly of worsted. The chief seat of these branches is Leicester and its neighbourhood, and Hinckley; the chief country villages also partake in them. At Ashby are considerable cotton-works. Harborough is the seat of a considerable manufactory of tammies. At Hinckley and Ashby, a good many hats are manufactured. Latterly, patent net-lace has become an object of great attention in Castle Donnington and its neighbourhood. The principal exports of the county, chiefly by means of the Trent, are, worsted stockings, hats, cottons, lace, wool, and cheese. Sheep are sent to Birmingham, London, &c. These two towns, and the populous parts of Staffordshire, take off a large quantity of the cattle of this county.

The poor-rates in Leicestershire, in the year 1776, amounted to the sum of 26,360*l.*; in the year 1803, they had advanced to 107,568*l.*: the increase, therefore, was nearly as 10 to 40¾. In the same period, the poor-rates of the whole kingdom had advanced from 1,679,585*l.* to 5,161,813*l*, or from 10 to 31 nearly: hence it appears, that they had increased in this county in rather a greater ratio than in the whole kingdom. The number of persons relieved in and out of work-houses, in the year 1803, was 19,154, besides those that were not parishioners. Each person relieved out of any workhouse at the rate of 3*l.* 13*s.* 8½*d.* per annum; each person relieved in the workhouses cost at the rate of 11*l.* 4*s.* 6½*d.* per annum. Taking both classes together, the expence per individual amounted to 4*l.* 7*s.* 3¾*d.* The resident population, in 1801, amounted to 130,081; so that the number of parishioners relieved from the poor-rates appears to be 15 in 100 of the resident population. The amount of the total money raised by parochial rates was 16*s.* 6½*d.* per head on the population. The amount of the whole expenditure on account of the poor averaged 12*s.* 10¼*d.* on the population. The number of persons belonging to friendly societies appears, in 1803, to have been 8 in the 100 of the resident population. One hundred of these societies had been enrolled according to act of Parliament. In the year ending 25th of March, 1815, the amount of money raised by parochial rates in this county amounted to rather more than 140,150*l.*

When the Romans invaded Britain, Leicestershire was inhabited by a tribe called the Corani. On their conquest, it was included within the province of Flavia Cæsariensis, and had military stations established in different parts of it, which were connected, as usual, by military ways, the most celebrated of which were the Watling-street and Fossway. When the Romans left the island, Leicestershire formed part of the kingdom of Mercia, and Leicester was constituted a bishop's see much about the time that England was divided into counties. Before this period, the kingdom of Mercia was subdivided into two parts, distinguished by the names of Southern and Northern. The inhabitants of Leicestershire were then called Middle Angles. Although this county lies, it may be said, in the centre of the kingdom, it was much subject to the ravages of the Danes, who constituted and regarded Leicester as one of their five chief cities in the island. After the Norman conquest, it was entirely parcelled out by William among his relatives and favourites, who, on their part, regranted various allotments to their followers and dependants. At this period, Leicestershire contained as great a number of strong castles as perhaps any district in the kingdom, most of which, however, were utterly demolished in the reigns of Henry II. John, and Henry III. When Domesday Book was compiled, there were only four wapentakes, or hundreds.

The whole county, at the time of the compilation of Domesday, is said to have contained 34,000 inhabitants; in the year 1700, the number was 80,000; in 1750, the number was 95,000.

According to the population returns of 1801, there were at that time 25,992 houses, and 130,082 inhabitants. By the returns in 1811, there were 30,019 houses, and 150,419 inhabitants.

LEIGHTON, Robert, was the eldest son of Alexander Leighton, a native of Scotland, but a minister in England, whose publications in support of the puritanical tenets drew upon him the vengeance of Bishop Laud, and subjected him (besides the indignity of having his ears cut, and his nose slit,) to a cruel imprisonment for the space of eleven years. His son Robert was, from his youth, distinguished by the most humble piety, and at the same time by the most promising talents. He was sent to complete his education in Scotland, where he made considerable progress in the learned languages; and afterwards spent some years on the continent, where he acquired a ready use of the French tongue. Upon his return to Scotland, he was ordained minister of Newbottle, in the neighbourhood of Edinburgh, where he devoted himself to his clerical studies and pastoral duties, without taking much concern in the political and theological contentions which so much prevailed in those days. In 1648, he declared his approbation of the measures in favour of the king, but was protected by the Earl of Lothian from the violence of the opposite party; and, when censured at the meetings of synod for neglecting to preach the duties of the times, is said to have replied, "If all the brethren have preached to the times, may not one poor brother be suffered to preach about eternity."

Finding it impossible, with all his moderation, to avoid sharing in the disputes of that period, he resigned his charge, and withdrew to a private station; but was soon after called from his retirement to preside over the college of Edinburgh, an office which he discharged, for the space of ten years, with great fidelity and approbation. During the terms of vacation, he made frequent excursions to London, where he had opportunities of observing all the eminent men of Cromwell's court; and occasionally also visited the Netherlands, where he seems to have found among the Jansenists a greater congeniality of views on his favourite idea, of reviving the purity and simplicity of the primitive ages of the Christian church. He seems to have considered the form of church government as a matter of comparative indifference, and as not very strictly defined in sacred scripture; but may be supposed to have been impressed by his father's sufferings with a feeling of aversion, rather than of attachment, to the constitution of the English hierarchy; and, when the measure of introducing Episcopacy into Scotland was adopted, he certainly showed great reluctance to accept the promotion which was pressed upon him. Having at length consented, (chiefly, it is said, through the persuasion of his brother, Sir Elisha Leighton,) he made choice of Dunblane, a small diocese, and poor revenue, to which, however, the deanery of the chapel-royal was annexed. He appears, from the beginning, to have augured little good from the measure in which he concurred; and remarked upon the feasting and jollity, which attended the consecration of himself and his associates, "that it had not such an appearance of seriousness and piety, as became the new modelling of a church." He was soon farther discouraged, by finding no support in his conciliatory plans of union with the Presbyterians, or in his Christian views of promoting sober piety and orderly worship among all denominations, which he regarded as more important than the mere form of government. His colleagues discovered no disposition to co-operate in his schemes, or to propose any other scheme of their own but compulsion; and "before they reached Edinburgh, they were (as he said to Bishop Burnet) as weary of him as he was of them." He left them at Morpeth, and refused to join in the pompous entrance which they made into the metropolis. He declined also taking his seat in the first session of parliament which followed their arrival; and indeed never appeared in that assembly, except when some measure came before them relative to religion or the church. He particularly exerted himself to procure liberty for the Presbyterian ministers to take the oath of allegiance with the explication which they tendered; and when he found that he could not concur in the oppressive measures which were pursued, he repaired to court in 1665, when he laid his sentiments on the matter before the king, and requested leave to resign his bishopric. This proposal of resignation was refused; but Charles promised to direct a change of measures; and is said to have been more friendly to Leighton's views than any of his counsellors. The good bishop in the mean time devoted himself to the business of his own diocese, in which he gave an example of personal piety and professional duty, which all parties might have done well to imitate. He regularly went round his district every year, preaching and catechizing from parish to parish, and labouring to raise his clergy to a higher sense of spiritual matters. He lived in a very private manner, and gave all his income to the poor, except what was requisite for his personal expences. In the hope of bringing about a general accommodation, and in consequence of promises of assistance from the court, he was persuaded, in 1670, to become Archbishop of Glasgow, where he exerted himself to the utmost to reconcile the contending parties. But at length perceiving that he gained nothing upon the Presbyterians except their esteem, and that he was suspected, and even hated by the Episcopal leaders, he resigned his charge in 1673, and retired to a private residence in Sussex. But, though he resigned his preferment, he did not relax his professional labours; but divided his time between studious retirement, and the clerical offices of preaching or reading prayers in the adjoining parishes. He retained to the last an appearance of greater youthfulness and strength, both of mind and body, than is usual in advanced years. At the age of 70 his hair was still black, and his motions lively; and his quickness of thought, power of memory, and spirit of devotion, in no respect impaired. But on a visit to London in 1684, he was suddenly seized with a pleurisy, of which he died in a few hours, at the Bell inn, in Warwick Lane. "He was accounted a saint," says Bishop Burnet, "from his youth up. He had a great quickness of parts, a lively apprehension, with a charming vivacity of thought and expression. He had the greatest command of the purest Latin that ever I knew in any man. He was a master both of Greek and Hebrew, and of the whole compass of theological learning, chiefly in the study of the Scriptures. But that which excelled all the rest was, he was possessed with the highest and noblest sense of divine things that ever I saw in any man. He had no regard to his person, unless it was to mortify it by a constant low diet, that was like a perpetual fast. He had a contempt both of wealth and reputation. He seemed to have the lowest thoughts of himself possible, and to desire that all other persons should think as meanly of him as he did himself. He bore all sorts of ill usage and reproach like a man that took pleasure in it. He had so subdued the natural heat of his temper, that in a great variety of accidents, and in a course of twenty-two years intimate conversation with him, I never observed the least sign of passion but upon one single occasion. He brought himself into so composed a gravity, that I never saw him laugh, and but seldom smile. And he kept himself in such a constant recollection, that I do not remember that ever I heard him say one idle word. There was a visible tendency in all he said to raise his own mind, and those he conversed with, to serious reflections; he seemed to be in a perpetual meditation. And, though the whole course of his life was strict and ascetical, yet he had nothing of the sourness of temper that generally possesses men of that sort. His thoughts were lively; oft out of the way and surprising, yet just and genuine. And he had laid together in his memory the greatest treasure of the best and wisest of all the ancient sayings of the heathens as well as Christians, that I have ever known any man master of; and he used them in the aptest manner possible." His sermons are full of sublime and Christian sentiments; his style combines, in a wonderful manner, a majestic force with a beautiful simplicity; and his pronunciation as a preacher is said to have been at once grave and graceful. His extreme modesty rendered him inexorable to all the intreaties of his friends to publish any of his writings during his life; but he was very careful in the preparation of his discourses; and many of his works have been recovered since his death. The chief of those which have been published are, a volume of sermons, with an exposition of the Creed, Lord's Prayer, and Decalogue; an exposition of the first epistle of Peter; meditations on certain psalms, originally in Latin; theological prelections in the same language; a few lectures and letters. See Bishop Burnet's *History of his own Times;* life of Leighton prefixed to his volume of *Sermons;* and preface to his *Exposition of Peter*, by Dr. Doddridge. (*q*)

LEIGHTON Buzzard, or Beaudesert, is a considerable market-town of England, in the county of Bedford. It is situated on the river Lyssel, or Ouzel, and consists of one large street, crossed at right angles by two smaller ones. The principal piece of antiquity in the town, is its beautiful pentangular cross. It is 38 feet high, and consists of two stories. It is built of stone, and situated in an open area in the market-place, and is supposed to have been erected about the beginning of the fourteenth century. The church is a large structure, and has a square tower surmounted with a spire 195 feet high. The Grand Junction Canal passes on the west side of it, and within a furlong of the town, and is capable of carrying vessels of 80 tons. About half a mile from the town are the remains of a Roman encampment. The population of the parish, in 1811, was 408 houses, and 2114 inhabitants. See Britton's *Architectural Antiquities of Great Britain*, vol. i.; Lyson's *Magna Britannia*, vol. i.; and *Beauties of England and Wales*, vol. i. p. 36.

LEINSTER. See Ireland.

LEIPSICK, or Leipzig, is a city of Misnia, in Upper Saxony, and situated on the Pleisse, in the fertile plain between the rivers Saale and Mulda. The town is neat and regularly built, and is about 8954 paces in circumference. The suburbs are extensive, and consist of good buildings and gardens, and is separated from the town by a fine walk of lime trees, which runs round the town. The Grand Place is large, and contains many excellent houses. The citadel, called Pleissenbourg, from its being situated on the Pleisse, is a place of great strength. It is erected after the model of the ci-devant citadel of Milan. It contains a moat, finished in 1752; and in its Roman Catholic chapel there is a monument to Jablonowsky; and on one of its towers is the observatory. Leipsick contains eight parish churches for Lutherans, and one for Calvinists. The church of St. Thomas has a fine organ, and its tower is 200 feet high. The exchange is a good building, and the roof of its hall is well finished. The other remarkable buildings and objects of curiosity at Leipsick, are the Maison Dufour, which is one of the finest edifices in Leipsick; the theatre; the manege; the Hotel de Ville, built in 1656; the house and the court of Auerbuch, built by the physician Strohmer; the auditory of M. Plattner; the concert room at the old assembly; the church of St. Nicholas; the college of princes; the Paulinum, a vast and ancient edifice, in the garden of which is a monument to Gellert; the hospital of St. George; the Lazaretto, and the clinical institution; the esplanade, with a statue of the reigning king; the monument of Gellert in the church of St. John, and his tomb in the public cemetry.

The principal literary and useful establishments in Leipsick, are the university, which was founded in 1409, and has always maintained its celebrity as a place of learning, and which has six handsome colleges belonging to it; the two public schools; the Academy of Painting and Design; the Economical Society; the Society of the Sciences of Belles Lettres, founded by Prince Jablonowski; the *Collegium Philo biblicum;* the Institution for the Dumb and Deaf; the *Intelligenz Comptoir*, with its numerous collections of machines and models; the Museum of Beygang, an excellent institution, which deserves the notice of travellers.

The chief collections and cabinets, are the libraries of the city, the university, and the churches and schools of St. Nicholas and St. Thomas; the cabinets of painting of M. M. Richter and Stieglitz; the cabinet of natural history of Link; the physical cabinet of M. Tauber, and the mineralogical cabinet of M. Hansen and M. Geissler.

Leipsick is a place of considerable trade, and possesses some important mercantile privileges. Three great fairs are held annually; at the beginning of the year, Easter, and Michaelmas, which continue during a fortnight each, and are frequented by foreigners from all parts of Europe, and even from Asia. The Bohemians bring all kinds of glass ware, linens, &c.; the Silesians bring linens; the Poles, leather, wax, and wool; the Prussians and Pomeranians, woollen and silken stuffs; the Nurembergers, toys; the Swabians, linens and gold and silver articles; the Austrians and Hungarians, leather, wines and dye stuffs; the Swiss, woollen, silken, and linen stuffs; the Russians, leather, hemp, and flax; the Italians, silk; the French, lace and milinery; and the English, Dutch, and Hamburgers, colonial produce and British manufactured goods.

The general amount of the trade carried on at these fairs, has been estimated at twenty millions of rix-dollars per annum. The almanac of Leipsick contains the names and addresses of more than 800 foreign merchants, who frequent these fairs, exclusive of from 260 to 290 booksellers. The amount of books sold annually, has been calculated at 500,000 rix-dollars; and, for the accommodation of this trade, the booksellers have recently established an exchange for the sale of books. Its principal manufactures are silk, gold and silver stuffs, linen and cotton printing, velvet, leather, carpets, hats, tobacco, paper, playing cards, Prussian blue, &c.

Leipsick is a depot both for foreign and Saxon merchandise, and the export of linens, silks, velvets, and velveteens, made in the neighbourhood of the town, is very considerable. These, along with leather and smalts, which are also exported, are shipped at Hamburgh, from which Leipsick procures her supplies of colonial and other foreign produce.

There are many promenades and public gardens around the town, which are deserving of notice. About three-fourths of a league from Leipsick, between the great road of Magdeburgh and Dessau, is the field of battle of Breitenfeld, celebrated by the defeat of Tilly. The field of battle of Lutzen is also near the town; and the spot where the French army under Bonaparte was totally defeated by the combined forces of the allies in 1813. Population of Leipsick 33,000. East Long. 12° 21′ 45″. North Lat. 51° 20′ 16″. See Rordansz's *European Commerce*, Lond. 1818, and our article FRANCE.

LEITH, is a sea-port town, and burgh of barony of Scotland, situated on the Frith of Forth, in the county of Mid-Lothian. It stands upon the Water of Leith, which divides it into two parishes, called North and South Leith, and is about two miles distant from Edinburgh. These two parishes communicate by two drawbridges. By far the greater part of the town is situated on the south side of the river; but both in North and South Leith, the streets of the old part are narrow and irregular, and they contain many excellent and commodious houses. The principal street is called the Kirkgate, and is as it were a continuation of Leith Walk. The parts of the town, however, which have been erected during the last 20 or 30 years, such as St. John's Place, St. James' Street, Cassilis Place, and the new streets in North Leith, to the east of the battery, and near the new church, contain most elegant houses, which are inhabited by the principal merchants, &c. and are not surpassed by the finest buildings in Edinburgh.

Leith contains several charitable establishments, the most important of which are the Female Society for relieving indigent and sick women; an Auxiliary Society for promoting Christianity among the Jews, and for aiding the British and Foreign Bible Society in London; a Society for the Relief of the Destitute Sick; a Sympathetic Society; a Female School of Industry; and a Boys Charity School.

In consequence of Leith having been pillaged and burnt by the English soldiers, when the Earl of Harcourt invaded Scotland in 1541, Leith was rebuilt and fortified. The fortifications, however, were subsequently demolished, to prevent any invasion of the liberties of the country from the introduction of foreign troops. New fortifications were again erected by Oliver Cromwell, who built the citadel, the remains of which still exist. It consisted, at that time, of five porticos, two of which were demolished at the Restoration, and the sale of the whole granted to the Duke of Lauderdale, then prime minister for Scotland, and from him the magistrates of Edinburgh purchased it for the sum of 6000*l*. The remains of the fortification are still visible between the Yard-heads and the Water of Leith, and also on the links of Leith.

Leith is defended by a fort, situated immediately to the westward of the town. The battery, which is a semicircular one *en barbette*, is mounted with nine heavy pieces of cannon. It was erected during the American war, for the protection of the harbour and shipping, in consequence of the alarm excited by the appearance of Paul Jones' squadron in the Frith of Forth; since which period the boundaries of the fort have been greatly extended, and surrounded by a high wall. It is now the head-quarters of the royal artillery in North Britain, there being two companies of that corps stationed there, under the command of a field officer. The barracks are capable of containing 350 men, and there are stables for 150 horses. There is also a large powder magazine and extensive warehouses erected within the fort, in which are deposited a large train of field artillery, with a suitable proportion of ammunition and stores. The harbour of Leith is defended by a fine martello tower, rising from the sea, at the distance of about a quarter of a mile from the pier. It was built during the late war, at a very great expence.

Whether we consider the port of Leith, in connection with some of the most interesting and eventful periods in the earlier history of Scotland, or as a modern port, in regard to the extent of its harbour works, and the number of its ships, we shall find it equally deserving our attention. In Leith, the extension of the quays have kept pace pretty nearly with the trade of the port; and even in some instances the extent of birthage may be said to have preceded the demand of the shipping, probably from the command of the necessary funds arising from its powerful connection with the metropolitan city of Edinburgh.

In the former state of the foreign trade and commerce of the Firth of Forth, it was much divided with numerous towns on the coast of Fife, but this now seems to be confined to the ports of Leith, Grangemouth, Dundee, and Aberdeen. It is, accordingly, curious to trace the progressive advancement of the quays and piers of the harbour of Leith, from small beginnings, to works of the present magnitude. In early times, when the vessels employed in trade were of a much smaller class, there were no quays at Leith; and the vessels lay at the mouth and on the banks of the small river, or stream, which runs through the harbour. A breast wall, or quay, was first built by the city of Edinburgh, some time after their purchase of Leith, with the adjoining lands, from Logan of Restalrig, which seems to have extended no farther toward the north than St. Bernard Street, but the work was afterwards continued to the signal tower, or ferry-boat stairs. In this state it remained for a long period, when it was prolonged to the northward, somewhat in the form of a crescent, by the extension of the wooden and stone piers. Perhaps the immediate inducement for the latter works was very much with a view to provide against the ravages which the sea was making upon the shore between Leith and Newhaven, which was endangering the safety of the citadel, and had already taken away a great piece of land on which a rope-work had been established.

About the latter end of the eighteenth century, however, the trade of this port had so much increased, that the merchants of Leith required further accommodation for their shipping; and an act having been obtained for increasing the shore dues, in the session of Parliament of 1800, a design having also been furnished by John Rennie, Esq. civil engineer, for a magnificent suite of wet docks, which has since been partly executed in the most substantial style of workmanship, under the inspection of Mr. John Paterson. The first of these beautiful basins, occupying an area of nearly four acres, commenced in the year 1801, during the provostship of Sir William Fettes, Bart., which was opened for the use of shipping in the year 1806. A second dock was afterwards begun in 1810, and completed in 1817. These two docks, comprehending nearly eight acres, together with three graving docks, the purchase of property, &c. it is believed have cost about 250,000*l*., raised partly by transferable bonds, granted upon the security of the city of Edinburgh, together with an advance, or loan, from government of 60,000*l*. But when the whole of this magnificent design is executed, it will extend to about twenty-three acres; and, according to the calculation of Mr. Stevenson, civil engineer, who allows 2,500 square feet to the birthage of a vessel of 100 tons, these docks, together with the side harbour, will contain upwards of 500 sail of this class of shipping; and the expence of the whole, however, including the harbour at Newhaven, will probably require the sum of 5 or 600,000*l*. Sterling. From the unavoidably great expence which such a weighty undertaking has already cost, and the difficulties and expence still interposed between the new works and deep water, the merchants are rather apt to take up a desponding view of their own case; nor is it much to be surprised that the public feeling leans that way. Yet when we reflect on the progress of commercial improvement within the last 50 years, and look forward to the advancement of the country, we are inclined to take a more favourable view of this great undertaking, and in this we are borne out by many circumstances. The connection of Leith with the capital must always hold it up, while we every where see a continued demand for the additional birthage of shipping, not at Liverpool and London only, but in all considerable ports throughout the kingdom.

The only doubtful matter connected with the present state of Leith, is the want of a sufficient depth of water for the general trade of the port, until the new works reach Newhaven. But with the most laudable intentions, Provost Mackenzie and the present magistracy, entering deeply into the case, have undertaken some measures for the improvement of the entrance to the present harbour, as the one ultimately intended at Newhaven may, from the unavoidable expense, be very distant. One obvious advantage, in regard to the present harbour, would be to reduce the space between the south and north pier, which is so great as to render the access to, or exit from it, extremely inconvenient; and it may also be added, that in the present condition of the entrance to this harbour, it is perhaps without an example in the whole kingdom. It may, indeed, be tolerated as the access to a great bay of the sea, or natural harbour of large extent, but is surely unsuitable as the approach to a small tide-harbour, built on both sides with perpendicular walls or quays.

The trade of Leith is now very extensive. The merchants of Leith have 10 vessels employed in the Greenland whale fishery. They carry on an extensive trade with Russia, Denmark, and Sweden, and with Hamburgh, Ostend, and the sea-port towns in Holland. They trade also to the ports in the Mediterranean, and have begun to take a part in the direct trade to the West Indies and America. They have a very extensive trade with London, and other towns on the eastern coast of England; with the inland towns on the Frith of Forth; and also with Glasgow, by means of the Forth and Clyde Canal. What effect will be produced by the Union Canal between Edinburgh and Glasgow remains to be seen.

Ship-building is carried on to a considerable extent; and there are manufactories of sail cloth and cordage. Several saw mills, some of which were constructed by the celebrated engineer Mr. Brunel, have been erected upon the Water of Leith. There is an extensive distillery at Bonnington, belonging to the Messrs. Haigs, and two houses for the refining of sugar. Leith has long been celebrated for its ale. There are many breweries here; but we believe that of Mr. Giles is the most extensive.

Leith is governed by a baron bailie, appointed by the magistrates of Edinburgh. He sustains the character of admiral, and chooses two resident bailies, who act as his deputies.

The population of the parishes of North and South Leith, in 1811, was 20,363.

The meridian of the observatory of Edinburgh passes through Leith Fort.

LEIMMA. See Limma.

LEITRIM, is a maritime county of Ireland, in the province of Connaught, bounded on the north by the counties of Donegal and Fermanagh; on the east by Cavan; on the south by those of Cavan, Longford, and Roscommon; and on the west by Sligo. It is about 52 English miles long. Its greatest breadth is 16 miles, and its least 6 miles; and it contains 407,260 English acres.

This county is almost entirely covered with groups of mountains, which are not wholly barren, but afford sufficient herbage for the breeding of cattle. Towards the sea the mountains are wild and lofty, and are separated by deep vallies. The principal of these are the Sliebhanewr and the Dartry, the last of which rises to an immense height. The huge mountain of Sliebh-an-Erin, which is near the middle of the county, separates the mountainous from the level barriers, which form the southern part of the county.

The river Shannon is said to have its origin in this county at Lough Clean, though this, however, is claimed by a spot near Florence Court, in the county of Fermanagh. Mr. Wakefield believes, that both these opinions are true, and that the Shannon is derived from two rivulets, which afterwards unite. From Lough Clean, which is a small lake, the Shannon flows into Lough Allan, a lake about 30 miles round, and 7 miles long, which lies in the centre of the county. There are several other lakes and small streams, which abound in trout, pike, eel, perch, and bream.

The minerals of this county are numerous and valuable. Iron ore occurs in great quantities in the high grounds, and it is also found in deep and rich beds in the low grounds. Copper and lead, a variety of clays, and plenty of limestone, are also found. Rich veins of coal have been wrought at Arigno. The seam is in a mountain near Lough Allan, the summit of which is a bog. These collieries belonged originally to a company of the O'Reilly's, upon whose failure it fell by mortgage into the hands of the Latouches. The coal is not of a good quality, and has been employed principally in founderies.

The manufactures of Leitrim, particularly that of linen, are improving rapidly. There are several bleaching greens in the county, and numerous potteries near Leitrim and Dromahare.

About a century ago, Leitrim was a continued forest; and immense heaps of charred timber are still seen at Dromshabo. A great deal of wood has lately been planted.

The principal town of the county is Carrick, which does not contain above 100 houses. Leitrim, about three miles north-east of Carrick, is not considerable enough to be a great town.

Dr. Beaufort estimates the number of houses in this county at 10,026, and the population at 50,000. Dr. M'Parlan, who took the number of families in each parish from the books of each individual parish clergyman, found that they amounted to 15,326, which he multiplied by 5, and obtained the population of 76,630. The majority of the inhabitants are Catholics. Mr. Wakefield estimates the proportion to be as 30 to 1, the same as in the county of Sligo. There are 17 parishes in the county. See M'Parlan's *Survey of Leitrim;* Beaufort's *Memoir of a Map of Ireland;* Robertson's *Traveller's Guide;* and Wakefield's *Statistical Account of Ireland*, passim.

LEMNISCATE, is the name of a curve which resembles the figure 8. The equation of the curve is $a^2 y^2 = a^2 x^2 - x^2$.

LEMNOS, now *Stalimene*, is an island in the Grecian Archipelago, belonging to Turkey. It is about 15 miles long and 11 broad, and abounds with mountains and valleys. The whole of its eastern coast is inaccessible, on account of a shoal which stretches four leagues into the offing. On the west coast, there are a few places of shelter for vessels against northerly winds. There is a large road on the north of the island; but on the south there are two real harbours, Port Cadia, and Port Sant Antonio, which are not very far from each other. The island of Lemnos is hilly, but very fertile. Its products are corn, cotton, oil, and silk, which is used in the manufacture of a few light stuffs. Sonnini observed here a spring of hot water, and another of aluminous water. The species of bole, called Lemnian earth, is still obtained from a hill in the island. This earth was formerly dug up with many religious ceremonies. The principal Turkish and Christian inhabitants met on the 6th of August at a chapel called Sotera, half way between the village of Cochino and the mountain where the earth is found, and thence they went in procession to the top of the mountain, where Greek priests read the liturgy. Certain persons appointed on purpose then began to dig, and as soon as they discovered a vein of the desired earth, they announced it to the priests, who put it into small hair bags, which they delivered to the Turkish governor and other officers. The excavations are then filled up, and the procession returns back as before. Some of the hair bags are sent to the Turkish emperors, and the rest, marked with his seal, or with the words *Tin imachton*, or *sealed earth*, is sold by the sangiak, or his deputies, to the inhabitants, or to foreign merchants. The sangiak accounts annually to the Grand Signior for his sale of the earth; and the inhabitants are capitally punished, if they in any shape export or trade in that earth without the permission of the sangiak. The two chief places in the island are Cochino, formerly Hephestias, and Lemno or Stalimene, formerly Merinea. East Long. 25° 16′, North Lat. 39° 54′. See Sonnini's *Travels in Greece and Turkey*, p. 504.

LENA. See Russia.

LENS. See Optics.

LEO X. Pope, the second son of Lorenzo di Medici, was born at Florence in the month of December, 1475, and was baptized by the name of John. Having been destined by his father for the church, he received the tonsure at the age of seven years; and being then declared capable of ecclesiastical preferment, he obtained, at a very early period, through the interest of his family, no less than twenty-nine benefices. In 1488, during the pontificate of Innocent VIII. he was elevated to the rank of cardinal, when only thirteen years of age. His early education was entrusted to that eminent scholar, Angelo Poliziano, assisted by other learned men, who frequented the Medici palace; and the success of their instructions was greatly promoted by the uncommon gravity and solidity of his disposition. In 1492, he was formally invested with the purple, and immediately went to reside at Rome, as a member of the sacred college. In consequence of his opposition to the election of Pope Alexander VI. he found it prudent to withdraw to Florence, in which place he acquired much personal respect; but on the invasion of Italy by Charles VIII. of France, he was involved in the expulsion of his family, and obliged to take refuge at Bologna.

In 1499, the cardinal, accompanied by his cousin Giulio di Medici, and a small party of friends, made a tour through the states of Venice, Germany, and France; and returning by Genoa, he soon afterwards went to Rome, where he fixed his residence, and in consequence of his prudent behaviour, was enabled to live safe and respected during the remainder of Alexander's pontificate. During the earlier part of that of his successor, Julius II. he continued to reside at Rome, cultivating polite literature, enjoying the pleasures of polite society, and indulging his taste for the fine arts. To the exercise of the chase he was passionately addicted.

In 1505, when he had attained his thirtieth year, he began to take an active part in public affairs; Julius, on his seizure of Perugia, having appointed him to its government. Adhering with firmness to the interest of the Pope, he acquired the confidence of his holiness to such a degree, as to be entrusted with the supreme direction of the papal army in the holy league against the French, in 1511, with the title of legate of Bologna. At the bloody battle of Ravenna, in 1512, he was taken prisoner, and conveyed to Milan, where the dignity of his sacred office procured for him a respectable treatment. He contrived, however, to effect his escape, and returning to Bologna, he assumed the government of the district, in the capacity of the Pope's legate.

On the death of Julius II. the Cardinal di Medici was elected to the pontificate in the month of March, 1513, being then in the thirty-eighth year of his age. He assumed the name of Leo X. and ascended the papal throne with greater demonstrations of good will, both from Italians and foreigners, than the greater number of his predecessors. His love of literature was displayed, by the appointment of two of the most elegant scholars of the age, Bembo and Sadoleti, to the office of papal secretaries.

The first object to which the efforts of the new Pope were directed, was the liberation of Italy from the dominion of foreign powers. With this view, he took into pay a large body of Swiss troops, by whose valour and discipline the bloody victory of Novara was gained over the French, who were in consequence forced to abandon Italy. The king of France, Louis XII. who had incurred ecclesiastical censure, made a formal submission, and received absolution. Having thus, in the first year of his pontificate, secured internal tranquillity, the attention of Leo was next turned to the encouragement of literature, and the patronage of men of genius. His first care was to restore to its former splendour the Roman gymnasium, or university, by means of new grants of its revenues and privileges, and by filling the professorships with distinguished characters from all quarters. Under the direction of Janus Lascaris, a college of noble Grecian youths was founded at Rome, for the purpose of editing Greek authors; and a Greek press, under the superintendance of Lascaris, was established in that city. Public notice was given throughout Europe, that all persons who should bring ancient manuscripts to the Pope would be liberally rewarded, besides having them printed at the expense of the holy see. Leo also endeavoured to promote the study of oriental literature, by founding the first professorship in Italy of the Syriac and Chaldaic languages, in the university of Bologna.

On the death of Louis XII. and the accession of Francis I. to the throne of France, it soon became apparent that the flame of war would be rekindled in the north of Italy. After some ineffectual attempts to preserve a neutrality, Leo at length found himself under the necessity of joining in a league with the emperor, the king of Arragon, the states of Florence and Milan, and the Swiss cantons, against the French king and the state of Venice. This league, however, was soon broken by the rapid success of the French arms, and the defeat of the Swiss in the battle of Marignano; after which the Pope found it expedient to detach his cause from that of his allies, and to form an union with Francis, the terms of which were arranged at an interview between the two sovereigns, which took place at Bologna towards the close of the year 115.

In the year 1516, Leo found a pretext to gratify his passion for aggrandizing his family, by excommunicating the Duke of Urbino, and seizing his whole territory, which, together with the ducal title, he conferred upon his own nephew Lorenzo. In 1517, the expelled duke collected an army, and by rapid movements completely recovered his capital and dominions. Chagrined at this event, the Pope endeavoured to engage all the Christian princes in a crusade against him; and having raised an army under the command of his nephew, by a profuse application of the treasures of the church, the duke was at length compelled to resign his dominions upon honourable terms. In the same year, the life of the pontiff was endangered, and his moments embittered, by a conspiracy which was formed against him in his own court. Cardinal Petrucci, the principal author of this conspiracy, had formed a plan of destroying Leo by poison; but having failed in this attempt, he withdrew from Rome, still however maintaining a correspondence with his secretary. Some of his letters having been intercepted, he was decoyed to Rome by a safe conduct from the Pope; but on his arrival he was arrested, committed to prison, and finally strangled. His agents and accomplices in the plot were put to death with horrid tortures; and some of the other cardinals were degraded, and subjected to heavy fines. In order to secure himself against any future disaffection, Leo created thirty-one new cardinals in one day, many of them consisting of his own relations and friends, and some whose talents and virtues rendered them worthy of such dignity.

Under the pontificate of Leo, the severest wound was inflicted upon the church of Rome, by the rise of the Reformation under Luther. The boundless profusion of the Pope having completely exhausted his treasury, he resolved to replenish his coffers by the profits arising from the sale of indulgences. The efficacy of these wares was extolled in such scandalous and extravagant terms, as could hardly fail of giving offence to pious and thinking men. Luther warmly protested against this abuse, calling in question the authority of the pope to remit sins, and making some severe strictures on this method of raising money. Leo seems to have treated the matter at first very lightly; and when his interference became necessary, he shewed a disposition to adopt lenient measures. All attempts, however, to effect a reconciliation proved fruitless; the breach became daily wider; and in the month of November, 1518, Leo published a bull, asserting the pope's authority to grant indulgences, which will avail both the living and the dead in purgatory. The works of Luther were burnt in different places by Leo's command; and Luther, upon his part, made a solemn and public conflagration of the papal decrees and constitutions, and even of the bull itself. But the circumstances connected with the rise and progress of the Reformation will be more properly related in another place. It was this pontiff who rewarded the controversial talents of Henry VIII. of England, by conferring upon him the title of Defender of the Faith.

The state of tranquillity which Italy enjoyed, at this period, permitted the Pope to indulge his taste for magnificence in shows and spectacles, and in the employment of those great artists who have reflected so much lustre on his reign. His private hours were chiefly devoted to indolence, or to amusements, some of which are said to have been of a trivial nature, and little suited to the dignity of his station. He was not, however, so much engrossed by these pleasures, as to neglect any opportunity of aggrandizing his family or his see. By the death of his nephew, Lorenzo, the duchy of Urbino, with its dependencies, became annexed to the Roman see; and other acquisitions were made by less justifiable means. Baglioni, chief of Perugia, was decoyed into the power of the Pope, tortured, and put to death, and his territories incorporated with the papal dominions. The city of Fermo was seized by a body of papal troops, and Frederic, the commander of the town, killed by them in attempting to make his escape. Leo even made an attempt to get possession of the city and territory of Ferrara, which, however, proved unsuccessful. In the year 1521, he entered into a treaty with the emperor, for the establishment of the family of Sforza, in the duchy of Milan. For this purpose, he hired a large body of Swiss troops, which were suffered to march through the Milanese into Romagna. This army, in conjunction with the Spanish and German auxiliaries, took possession of Parma, which, together with Placenzia, was to be united to the domain of the church. The allies then crossed the Adda, and were received, without opposition, into Milan; the Swiss in the service of France having been prevailed upon to desert. They next entered the territory of the duke of Ferrara, against whom the Pope had already launched the thunders of the church. Several of his strong places were taken, and the siege of his capital was impending, when Leo, who had repaired to Rome, to be present at the public rejoicings for these successes, was attacked by an indisposition, apparently trivial, but so rapid in its progress, that after a week's illness he expired, on the 1st of December, 1521, in the forty-sixth year of his age, and the ninth of his pontificate.

His death was by some ascribed to poison, but of this there is no evidence.

Different opinions have been entertained with regard to the character of this celebrated pontiff, which, however, will be best estimated from the narrative we have given of the principal transactions of his life. Without giving credit to many of those enormities, with which he has been charged upon insufficient evidence, it will appear that Leo was far from exhibiting a pattern of integrity in his moral and political conduct. Self-interest seems to have been his ruling motive of action; and he shewed himself by no means scrupulous with regard to the means he employed for attaining his ends. His patronage of literature and the fine arts has been held out as the finest trait in his character, and as a sufficient atonement for all his faults. *The age of Leo X.* indeed, is generally referred to, as one of the most flourishing periods of art and literature in the annals of mankind. But, without derogating from that just share of merit which may be allowed to belong to Leo on this account, we may be permitted to observe, that many of the subjects of this celebrated age must be sought for beyond the sphere of his protection and influence; and that the patronage he bestowed may be ascribed, perhaps, more to his vanity, than to any real love of what is valuable in literature, or any genuine admiration of what is excellent in the arts. See Roscoe's *Life and Pontificate of Leo X.* (*z*)

LEOMINSTER, or **Lemster**, is a burgh and market town of England, in the county of Hereford. It is situated in a rich and fertile vale, abounding with orchards, hop-yards, fine meadows, and arable lands. The river Lugg runs on the north and east sides of the town. Two smaller streams flow through the town, and other three considerable rivulets pass within half a mile of it. Leominster is about a mile long from north to south, and about half a mile from east to west. There are many good modern houses built of brick; but, in general, the houses consist of timber and plaster, painted white and black, and adorned with curious grotesque carvings. The streets in the centre of the town are narrow, and the suburbs ill built. The church of Leominster is a large building, and irregular both in its form and architecture. The interior length is 125 feet, and its width 124. The church of Leominster was partly destroyed by fire on the 18th March, 1700, and was rebuilt at the expense of nearly 18,000*l.* Besides the church, there are four places of worship, viz. for the Baptists, Presbyterians, Moravians, and Quakers. The meeting-house of the Baptists is a neat building. The town-hall, or butter close, is a singular building of timber and plaster, erected in 1633. It stands on 12 oaken pillars. A new gaol was built here in 1750; and in 1803, a neat market-house was erected by the corporation for the sale of grain. It is a small building of the Tuscan order, with pediments and a capital.

The town is governed by a bailiff, chief steward, recorder, 24 capital burgesses, a chamberlain, two sergeants at mace, and some inferior officers. It sends two members to parliament, and the number of voters is about 500.

Cloth is the principal article of manufacture at Leominster. The manufacture of hats and gloves, and the tanning and dressing of leather, are carried on to a great extent. From the fertility of the surrounding country, Leominster has always been considered as one of the best markets for wool, wheat, and cyder. There is a free school here, two charity schools, an alms-house, and Sunday schools, to which the annual benefactions are considerable.

The population of the burgh and parish, in 1811, was 730 houses, and 3238 inhabitants. See *The Beauties of England and Wales*, vol. vi. p. 562—574

LEON, a province of Spain, situated towards the northwest, is bounded on the east by old Castile, on the south by Estremadura, on the west by Portugal and Galicia, and on the north by the Asturias. Its form is that of a long rectangular figure, about 52 leagues from north to south, and 30 at its mean breadth from east to west, lying between 40° and 43° north latitude, and between 4° 10′ and 5° 25′ west longitude. It was anciently the country of the Vettones, mentioned by Strabo, and, for a long period, formed a separate kingdom. After the defeat of Roderic, the Gothic king, at Xeres de la Frontera, its capital city Leon was taken from the Moors, in 1717, by Prince Pelagius, who had collected the dispersed Christians; and in 915, one of the successors of that prince took the title of King of Leon. In 1030, it passed to Ferdinand, surnamed the Great, then King of Castile, and was finally united with that kingdom in 1069.

This province is mountainous, but less so than many of those immediately adjoining. Its mountains are covered with trees, particularly oaks; and it contains many beautiful fields, luxuriant pasture grounds, and extensive vallies. The more remarkable mountains are those which form part of the Sierras of Pico and Occa, (formerly Mount Idubeda,) in the south-east part of the province. The principal rivers are the Douro, which enters the province from Arragon, and divides it into two nearly equal parts; the Carrion, which flows from Old Castile, and falls into the Douro at Simancas; the Eresma, which enters Leon at Macheda, and afterwards unites with the Douro; the Tormes, which rises near the southern extremity of the province, runs northwards to Salamanca, and thence north-west to the Douro, opposite Bemposta, on the frontiers of Portugal. Besides these, there are the Sil, the Buroia, the Sabor, the Baeza, the Arago, the Xero, the Pisuerga, and nearly as many more, which chiefly rise in the province or on its confines. There are several bridges over these rivers, particularly over the Douro. There is one below Benavento over the Ezla, consisting of nineteen arches; one of eighteen arches over the Porma, near Villa Rente; and another over the Tormes, at Alva de Tormes, of twenty-six arches, supposed to have been built by the Romans. There is a lake near Astorga, called Sanabria, about three miles long and half as much in breadth, through which the river Tuerto rushes with such force as to excite waves equal to those of the sea; and a rock rises in the middle of the lake, on which stands a fine old castle belonging to the Counts of Benavento.

In the mountains are found iron and copper mines, and a number of mineral streams. Four of these are cold springs, namely, at Amusco, Buron, Bavela Fuente, and Astudillo. There are also four warm fountains, namely, one near Almeyda, of a sulphureous appearance; one at Ledesma, where there is a public bath of a moderate heat, which is found useful in cutaneous diseases; one at Bonar, issuing from a rock, and of a lukewarm temperature; and one at Barnos, near the frontiers of Estremadura, serviceable in rheumatic and nervous complaints. Near Zamora, turquoises are found in the hills, and were formerly so abundant, that the Moors called it "the town of turquoises."

A great number of excellent mules are reared in the province, and considerable flocks of sheep and goats; and various kinds of fish are found in the rivers, particularly eels, barbel, and trout.

There are many fertile vallies in the province, particularly those of Mediano and Batuccas, and the soil is very productive in many districts, especially on the east point towards Portugal. The lower grounds also are free of trees, and agriculture might flourish in the province, were more attention paid to the irrigation of the land by its numerous rivers. The principal crops are wheat, oats, maize, flax, olives; and in some places, extensive vineyards, particularly around Barnos, where 25,000 arobas of wine are produced yearly. But cultivation, in general, is in a languid state; and many districts, capable of being rendered sufficiently fertile, are left in a state of nature. It is only in some of the richer tracts that fruit trees are found, particularly from Casas del Puerto to Villa Toro.

Formerly, very flourishing manufactories existed in several towns of Leon, especially in Ciudad Roderigo, where fine tapestries, embroidery, and laces were made, and where the best leather in Europe was prepared. But all these have greatly decayed. There are some cloth manufactories in a few of the towns, particularly at Orvas; one for hats at Zamora; for serges at Rio Seco; and some of hosiery and leather at Leon. The commerce of this province, therefore, consists chiefly in importation. Some wines, especially those produced in the south-east of the county, are exported; but those of the northern districts are so inferior, as neither to bear carriage, nor answer any market. A considerable portion of the coarser manufactures are sent into Galicia; and the madder produced in the vicinity of Ciudad Roderigo and Medina del Campo is conveyed through Portugal to the English merchants.

This province contains six bishoprics, viz. Leon, Salamanca, Palencia, Zamora, Astorga, Ciudad Roderigo; 2460 parishes, 196 convents, 23 hospitals, five asylums, two military governments, four intendancies of provinces, one university, four superior colleges, 25 colleges of all classes, six cities, 539 towns or boroughs, 2005 villages or settlements, of which 76, formerly inhabited, are now deserted. The principal towns are Leon, Astorga, Zamora, Toro, Palencia, Medina-del-Rio-Seco, Tordesillas, Villa Pando, Duenas, Marsilla, Villa Franca, Benevente, on the north of the Douro; and on the south of that river, Salamanca, Ciudad Roderigo, Alva de Tormes, Pena-Aranda, Pena-de-Francia, Carpio, Medina-del-Campo, and Ledesma. But many of the towns are not half inhabited; and the population has been recently much diminished. The present amount is estimated at 665,000 persons; of whom 5598 are secular priests, 2064 monks, 1570 nuns, 31,540 nobles, 25,218 servants, and the remainder of the other professions. The inhabitants of this province are distinguished by their gravity and taciturnity, and greatly resemble those of Old Castile. Among the mountains near Astorga are a race called Mauregatos, who preserve the remains of the ancient costume, in their pyramidal hats, neck-ruffs, short jackets, wide breeches, and spatterdashes. Their women wear large ear-rings, a kind of white turban widened like a hat, a chemise closed over the chest, a brown corset buttoning tight, with large sleeves, opening behind, brown veils and petticoats, and over all immense coral necklaces, passed several times round the neck and shoulders, gathered into a row or bandage over the bosom, and falling in successive rows down to the knee. (*q*)

LEON, the capital city of the last mentioned province, is situated between the two sources of the Exla, south from the mountains of Asturias, and is one of the most ancient towns in Spain. It was founded before the reign of Galba, and received its name from the circumstance of the Legio Septima Germanica having been stationed there. It was known at a very early period also as an episcopal see; and, in the time of the Gothic kings, possessed the privilege of appealing immediately to Rome. It was the first town of any importance recovered from the Moors; and was for three centuries after that period the residence of the first Catholic kings in Spain. It contains 13 parish churches, one collegiate church, four convents of monks, five of nuns, and a number of hospitals and hermitages. There are also the royal houses of San-Isidoro, and San-Marcos, of the order of St. James; and a chapter of noble canonesses, not cloistered, but who take the vows. But little now remains of its ancient splendour and population; and the exterior magnificence of its public buildings forms its principal boast and attraction. A great part of its walls is constructed of green marble; and at the bottom of one of the gates, which was formerly a famous prison, is a statue of King Pelagius. The ancient palace of its sovereigns, which stands close to the wall on the western side, is now in a decayed state, and has been converted into a cloth manufactory. The edifices most worthy of notice, and still in a good state of repair, are the monastery of the regular canons of St. Augustine, and the royal convent of St. Mark, which are both of tolerable architecture; the hotel of the Counts of Luna, which is a large and handsome building; the palace of the Guzmans, remarkable for its strong walls and superb portal; the town house, which has a tolerably regular front, and good appearance. The Place Mayor, opposite to the town-house, contains several beautiful and uniform buildings; and there are several squares and handsome fountains. But the great boast of the place is the cathedral church, which is esteemed one of the finest in Spain, and furnishes a beautiful specimen of Gothic architecture, distinguished for its height and boldness, just proportions, and admirable lightness of structure. It contains the tombs of one emperor, and 37 kings; and the shrines of several saints, particularly of St. Isidore and St. Vincent. There are a few manufactories of woollens, linens, stockings, and leather gloves; but the town is chiefly supported by the expenditure of the churchmen. The streets are covered with filth, and full of beggars, who are fed at the convents. The adjoining country is very beautiful, and is ornamented with numerous avenues of noble trees; but little is done in the way of cultivation; and the produce consists more of vegetables, fruits, and pastures, than of grain. The population of the town is estimated at 6000. (*q*)

LEON (ISLA DE), a town and insulated district in the vicinity of Cadiz, which has recently increased in popution and wealth; and forms a singular instance of a new and growing town in Spain. The island is formed by a canal which surrounds it, and which at high water is so deep (about 24 feet) as to admit the largest ships. This insulated portion is still farther separated from the continent by a marshy tract, through which a causeway is constructed; and the whole adjoining country is filled with salt pits, in which the heat of the sun makes the bay-salt, which is so important an article in the commerce of Cadiz. This northern extremity of the isle is remarkably strong both by nature and art; and may be considered as one of the principal defences of Cadiz. The road, which leads through the marsh, (which is impassable in any other way,) enters Leon by the bridge of Zuarzo, which is flanked with batteries, and defended by gun-boats. This bridge has evident marks of a Roman origin; but its modern structure is ascribed to a Dr. Sanchez Zuarzo, who died in Segovia in 1437. This island was so entirely deserted in the 17th century, that there was not a single house upon it; but at present the principal street of the town is two miles in length, with shops of every kind on each side of it; and the number of inhabitants above 40,000. Its extent is so considerable, that, including the suburb of St. Carlos on the north, it is supposed capable of containing double that number. The streets are wide, and the houses large; but, like other Spanish towns, it displays a strange mixture of grandeur and poverty. The hotel de ville, in the great square, is a handsome building; and the house of the Marquis d'Urena is provided with a well-chosen library, a philosophical apparatus, and a fine collection of paintings. The principal church equals most of the religious edifices of Spain in point of decorations; but one of the most striking objects in the place is the repository of the deceased ecclesiastics, called the Pantheon. This is an open court, of an oval form, with a corridor built on arches, and supported by pillars. In the walls, which are of competent thickness, are receptacles for the remains of the clergy, resembling the mouths of ovens, which after interment are closed with bricks, and of which Mr. Jacob reckoned five hundred. The town is much occupied by naval and military officers and establishments; and presents a busy animated scene. See Laborde's *View of Spain;* Burgoan's *Travels in Spain;* and Jacob's *Travels in Spain.* (*q*)

LEONIDAS, one of the kings of Sparta, who was appointed to check the progress of the Persian army at the pass of Thermopylæ, and who bravely devoted his life to the cause of his country. Coolly contemplating the desperate nature of the service assigned them, he and his little band, before leaving Lacedæmon, celebrated their own funeral rites, and took a final farewell of their relatives and friends. The general facts, of his determined and reasonable resistance to the overwhelming force of the invaders, are sufficiently established to warrant the eulogies which all succeeding ages have bestowed upon his magnanimous conduct; but a variety of circumstances, resting rather on the authority of tradition than of history, have been detailed by his partial countrymen, in illustration of the daring and deliberate courage by which he and his heroic band were animated in this patriotic enterprise. When reconnoitred by a Persian horseman, at their fatal post, they were observed exercising themselves in martial sports and decorating their flowing hair, according to the custom of their country. When haughtily required by the Persian monarch to lay down their arms, Leonidas returned the laconic reply, "Come and take them." When promised a kingdom from the invader, upon condition of surrendering at discretion, he gallantly replied, that "the Spartans were accustomed to acquire kingdoms by valour, and not by treachery." When informed that the Persians were so numerous that their darts would darken the sun, the answer was briefly given, "then we shall fight in the shade." When surrounded on the third day of the contest, and determined with his three hundred Spartans, and a few Thespian auxiliaries, to obey the law of his country, which prohibited retreat before an enemy, however superior in strength, "Come," he said to his fellow-soldiers, "let us dine cheerfully in this place, for to-night we shall sup with Pluto." When the last onset was made, Leonidas fell early in the fight, under a shower of javelins; and his undaunted followers, surrounding his dead body, died to a man on the spot. A monument was afterwards erected on the field of battle, with the following inscription by Simonides: "Tell, O stranger, the inhabitants of Lacedæmon, that we died here in obedience to her sacred laws;" and, for many years, it was the custom of the Spartans to pronounce funeral orations, and celebrate public games, on the anniversary of this battle, in honour of their heroic countrymen. See *Herodotus*, lib. vii.; *Diod. Siculus*, lib. xi.; *Pausanias*, lib. vii.; *Strabo*, lib. ix.; *Justin*, lib. ii.; Plutarch, *in Apophthegm. Lacon;* Mitford's *History of Greece*, vol. i.; Goldsmith's *History of Greece;* Morell's *Studies in History*, vol. i. See also GREECE, p. 465. (*q*)

LEONTINI, LEONTIUM, now LENTINI. See SICILY.

LEPROSY. See MEDICINE.

LERIDA, anciently ILERDA, is a town of Spain, in the province of Catalonia. It is situated on the declivity of a hill, on the west bank of the river Segra. The town is long, narrow, nearly triangular, and close and ill built. The streets are narrow, crooked, uneven, and paved with pointed stones unequally driven in. It has only one tolerable street, about one-fourth of a league long, which would have been handsome had it been wider. The quarter of the town towards the river is well situated, though gloomy within. A fine quay, extending the whole length of the town, has been lately built, and unites the double advantage of restraining the waters of the Segra, and of furnishing the means of amusement to the inhabitants. If planted with trees it would form a handsome promenade.

The principal edifice in Lerida is the cathedral, which has been lately built, but unfortunately stands in a narrow street. It is ascended by a double flight of twenty steps, which leads to a terrace, on which the gates of the church open. The front, which is of free-stone, has six fluted pilasters of the Corinthian order, between which there are three large doors, with iron gates of handsome workmanship. It has two fine square towers, terminating in round pavilions. At the top of the hill are the remains of a palace which the kings of Arragon had inhabited. There was formerly a university at Lerida; but it has now only a college, which is maintained by the bishop, and where sixty young clerks are instructed gratuitously.

A trade in salt fish was formerly carried on here, but it has now failed. Lerida now exports the productions of the adjacent territory, such as fruits and pot-herbs, to Urgel and Arragon. Silk worms are bred here, but to no great extent. The surrounding country, which is rich and productive, is intersected with canals, and is well watered. Population 18,000. See Laborde's *View of Spain*, vol. i. p. 82.

LERWICK. See SHETLAND.

LESBOS. See METELIN.

LESSER INTERVALS, in Music, are such as are lessened either 𝐒 or 𝒻: or, LESSER or MINOR *Intervals*, are such as are less than the *Major* INTERVALS of the same name, by the intervals 𝐒 or 𝒻, and even by S and 4 c; also in the discordant nomenclatures, followed by different writers, on Musical Intervals. (ϱ)

LESSING, GOTTHOLD EPHRAIM, a celebrated German author, was born at Kamenz, a town of Upper Lusatia, on the 22d of January, 1729. The first rudiments of instruction he received from his father, John Godfrey, the Protestant clergyman of Kamenz, a man of excellent character, who acquired some reputation from his theological writings. Having spent some time under the tuition of a private instructor, and at the public school of his native place, he was sent, in his twelfth year, to the free school at Meissen, where he remained five years, and acquired, by diligent study, an intimate acquaintance with the Greek and Latin languages. Some translations from Anacreon, which he executed while at this school, were afterwards published among his poems. He also applied with great zeal to the study of the mathematics; translated for his own use the second, third and fourth books of Euclid; and wrote an history of the mathematics.

From Meissen he repaired to the university of Leipsic. It was the wish of his father that he should study theology, with the view of taking orders; but this Lessing declined, conceiving that he did not possess the requisite qualifications. Hitherto he had been a diligent student; but finding that he had addicted himself too exclusively to books, to the neglect of bodily exercises, and the improvement of his mind by social conversation, he laid aside for a time all serious reading, and endeavoured to acquire those ornamental accomplishments, which might enable him to make a better figure in society. Poetry, and the *belles lettres* in general, particularly the drama, were now his favourite studies. He was a constant attendant at the Leipsic theatre, then under the direction of Madame Neuberin, with whom he contracted an intimate acquaintance; and made some attempts in dramatic composition. In the mean time, his father, who had been informed of his course of studies, and had hitherto with difficulty supplied his expences, strongly urged him either to take orders, or a medical degree; but Lessing declined to do either, and was now left to provide a subsistence for himself by the exercise of his talents. In a periodical work, published at Hamburgh by one M. Agricola, he gave the first specimens of his abilities as an author. He also made translations of French plays along with Weisse, and furnished poems for a periodical publication edited by his friend Mylius. The first dramatic piece which he published with his name was a comedy, entitled, *Der junge Gelehrte*, which was performed with success by the company at Leipsic. From Leipsic he was induced to remove to Berlin, in the hope of finding a better field for his literary exertions. Here, in conjunction with Mylius, he commenced a periodical work on the history and state of the stage, which, although written in a new and instructive manner, was discontinued after the fourth number. He next occupied himself with the publication of his poems, which appeared anonymously, under the title of *Trifles*. Soon after he repaired to Wittenberg, where he continued to prosecute his studies for about a year, and took the degree of Master of Arts. During this period he was employed in various literary occupations, in which he had an opportunity of displaying the force and the versatility of his genius.

Having become weary of his residence at Wittenberg, he returned to Berlin, where he renewed his acquaintance with the eminent men of that city, and contributed the literary article to a newspaper, which had previously been written by his friend Mylius. In 1753 and 1754, he published an edition of his miscellaneous writings in 4 vols. 12mo. which were well received, and contributed to extend his reputation. Berlin was at this period the residence of a considerable number of those men, to whose talents the literature of Germany has been most eminently indebted. Of this number were Moses Mendelssohn, the celebrated Jewish philosopher, Nicolai, the printer, Rambler, the poet, Salzer, the philosopher and critic, Süssmilch, the statistical writer, and several others of distinguished reputation. From the charms of this literary society, Lessing retired for a while to Potsdam, with the view of completing his tragedy, entitled, *Miss Sarah Sampson*. This was the first specimen of the *tragedii bourgeoise* which had appeared in Germany. It was received with great applause when first acted at Frankfort on the Oder, and was afterwards performed, with the same success, on various other theatres. It was also translated into the Italian, French, and Danish languages.

In 1755, he went to Leipsic. Here he was introduced to M. Winkler, a young man of fortune, who engaged him as the companion of his travels. Their journey, however, extended no farther than Amsterdam; for M. Winkler having received intelligence of the irruption of the Prussians into Saxony, thought proper to return home. Lessing now occupied himself, for some time, in translating several works from the English; and in composing a volume of original fables, in the manner of Æsop. In 1757, he became associated with Moses Mendelssohn and Nicolai, in the publication of a periodical work, entitled, *The Library of the Belles Lettres*, containing a review of works in polite literature, with original correspondence. He now returned once more to Berlin, and published his tragedy, *Philotas*. One of the most remarkable fruits of the intimacy that subsisted between Lessing, Mendelssohn, and Nicolai, was the joint production of the *Letters on Literature*; a work which acquired great celebrity, and which contributed perhaps more than any other publication to form the taste and style of the German writers. About the same time, Lessing published three books of fables in prose, to which he prefixed a treatise on the theory of the fable. In 1760, he was elected an honorary member of the Berlin Academy of Sciences.

Lessing now entered upon a new scene. Without giving the slightest notice, even to the most intimate of his friends, he set out for Breslau, as secretary to the Prussian General von Tauenzien. This appointment, which he had been induced to accept on account of his health, gave him an opportunity of acquiring more knowledge of the world. He became acquainted with almost all the officers of the Prussian army, in the seven years' war; but, unfortunately, his military associates gave him a taste for gaming, which impeded the progress of his literary pursuits. In the year 1765, he returned to Berlin, and resumed his former mode of life. He now published his *Laocoon*, a treatise on the limits of poetry and painting, for which he had collected the materials during his residence at Breslau. In 1766, he received an invitation from a society of lovers of the drama at Hamburgh, who made him advantageous proposals for his assistance in endeavouring to improve the theatre in that city. This invitation he accepted, and accordingly repaired to Hamburgh in 1767. Here he commenced his *Hamburgh Dramaturgy*, a weekly paper, which was afterwards published in two volumes, 8vo. forming a mass of valuable dramatic criticism.

Lessing's circumstances, however, were still very limited, and his prospects so little encouraging, that he had resolved to sell all his effects, and go to reside in Italy; where he fortunately met with a patron in Leopold, the hereditary Prince of Brunswick, through whose influence he was appointed librarian at Wolfenbuttel, and received the title of Aulic Councillor. Here he found ample materials for the gratification of his literary curiosity. A few days after he had begun to discharge the duties of his new office, he discovered an important M. S., the existence of which had been doubted, viz. the work of Berengarius of Tours, in which he refutes Lanfranc's book on transubstantiation. This work he intended to have published, had he met with encouragement. In 1771, he commenced an improved edition of his miscellaneous writings; of which, however, only the first volume appeared in his own lifetime. In 1772, his popular tragedy, entitled *Emilia Galotti*, was performed for the first time at Brunswick, and soon afterwards upon all the other German theatres. In the exercise of his functions, as librarian, he commenced a periodical work, under the title of *Contributions to history and literature, from the treasures of the ducal library at Wolfenbüttel*, of which the first number appeared in 1773.

The state of his health, at this period, induced him to undertake a journey to Berlin and Vienna; where he was received with very flattering attention. At Vienna, he became acquainted with a lady of great intellectual accomplishments, the widow of a merchant, with whom he united himself by marriage. Having accompanied the hereditary prince of Brunswick in a journey to Italy, he returned, after an absence of eight months. From this period he devoted himself chiefly to polemical divinity, and published the *Fragments of an anonymous Writer, discovered in the Library at Wolfenbüttel;* which involved him in a controversy with some of the German theologians, and ultimately occasioned the suppression of the *Contributions*, by the interference of the Consistory. His next publication was that singular drama *Nathan the Wise*, a piece which has been sometimes represented on the stage, but which is more calculated for the closet. The last effort of his pen consisted of a treatise *On the Education of the Human Race.* His health had been for some time in a declining state; and his constitution being at length completely exhausted, he expired on the 15th of February, 1781, in the 53d year of his age.

Lessing is generally considered as one of the most able and original writers whom Germany has produced. In his youth he had been an indefatigable student, which supplied him with a large stock of acquired knowledge. He possessed strong natural abilities, and his mind was ever actively engaged in literary and philosophical inquiries. As a poet, he is more remarkable for correctness than brilliancy of fancy. His dramatic pieces were, by his own confession, the offspring of laborious effort, combined with critical knowledge, rather than of any original talent for that species of writing. It is in his prose writings that the vigour of his genius is most conspicuous. These abound in able disquisition, profound and original remarks, and criticism at once judicious and acute. In this last respect, indeed, he deserves to be placed high in the ranks of literature, as one of the most eminent critics of modern times. An edition of his works has been published at Berlin, in thirty volumes 8vo. See *Lexicon deutscher Dichter und Prosaisten*, by Jördens; and *Denkwurdigh aus dem Leben ausgezeichn. Teutschen d. achtzehnt. Jahrh.* (z)

LETTERS. See Alphabet, Hieroglyphics, and Printing.

LEUCTRA, now Leftra, or Lefca, the name of a town of Greece, celebrated by the battle fought there between the Thebans and the Spartans. Dr. Clarke informs us, that the traces yet remaining of its ancient monuments are like those of a considerable city. The ground is covered for a considerable space with huge fragments of marble and stone, among which the inhabitants have long laboured to introduce the plough. "We saw them employed," says Dr. Clarke, "in breaking a huge *bas relief*, and labouring hard to remove the foundations of ancient edifices; but the remains of the trophies, temples, and walls of Leuctra, will resist their utmost unremitted efforts for a long time to come." See Clarke's *Travels*, vol. iv. p. 89, 90.; and Greece.

LEUWENHOEK, Anthony Van, a Dutch philosopher, who has been universally celebrated for the number and importance of his microscopical observations and discoveries. He was born at Delft in Holland, in the year 1632, and does not seem to have had the benefit of a learned education. Leuwenhoek was first recommended to the Royal Society by Dr. De Graaf, as a person who had made several microscopical discoveries by means of glasses contrived by himself, and surpassing even those of the celebrated Eustachio Divini. His first communication was sent to the Royal Society by Dr. De Graaf, in 1673, and is entitled, *Some Observations made by a Microscope contrived by M. Leuwenhoek in Holland.* His communications to the Royal Society became frequent and important, and amounted altogether to about 112 papers. He published also about 26 papers in the Memoirs of the Academy of Sciences. These papers were all collected into four quarto volumes, and published at Leyden in 1722, under the title of *Antonii a Leuwenhoek Opera omnia seu Arcana Naturæ ope exactissimorum Microscopiorum detecta, experimentis variis comprobata.*

Leuwenhoek was elected a fellow of the Royal Society of London in the year 1680. He was made a corresponding member of the Academy of Sciences at Paris in 1697, and received similar honours from almost all the learned academies in Europe.

When Queen Mary was in Holland, she paid a visit to Leuwenhoek, and was much delighted with his curiosities. He presented her with two of his microscopes, in testimony of his esteem. The success which attended Leuwenhoek's observations, seem to have arisen wholly from his having paid the most minute attention to the grinding and polishing of single lenses, which he always used in preference to the compound microscope.

M. Leuwenhoek died at Delft in 1723, and bequeathed to the Royal Society a small Indian cabinet, in the drawers of which were thirteen little boxes, or cases, each containing two microscopes handsomely fitted up in silver; of which, not only the lenses, but all the apparatus, were made with his own hands. Each microscope had an object placed before it; and the whole was accompanied with a description of the objects, in his own hand-writing. A fuller account of these will be found in the *Philosophical Transactions*, for 1723, vol. xxxiii. p. 446.

LEVEL and LEVELLING. See NAVIGATION *Inland*, but particularly SURVEYING.

LEVEN, LOCH. See KINROSS-SHIRE.

LEVEN, a village in the parish of Scoonie, and county of Fife, lies on the western extremity of Largo bay, at the junction of the river Leven with the frith of Forth, about nine miles north-east from Kirkaldy. It consists of two streets running parallel to each other, and several bye-lanes, which, owing to their being narrow and badly paved, are in general very dirty. In the neighbourhood, particularly on the estate of Durie, are several rich seams of coal, which, however, are not at present wrought. These formerly employed a considerable number of ships in conveying their contents to Holland; but this trade has for many years been discontinued, and the shipping belonging to this place has, in consequence, been greatly reduced. There are at present only two brigs and several sloops. The harbour, which is entirely a natural one, and formed by the mouth of the Leven, is capable of admitting vessels of about 200 tons, and of affording secure shelter to a considerable fleet; but it is rather difficult to take, especially when the wind is adverse. The river Leven issues from the east end of the loch of the same name, and runs a rapid course of nearly fourteen miles. The fall in that distance is above 300 feet, and it is thus peculiarly adapted for public works. In 1813, there were on this river ten spinning mills, two paper mills, two iron founderies, seven bleachfields, and twenty-eight corn and other mills, giving employment to about 6000 persons, and whose buildings and machinery were estimated at 176,220*l*.—The salmon-fishery here, which was formerly of some importance, is now very unproductive, owing, it is said, to the deleterious ingredients brought down by the river from the bleach-fields, &c.—The fairs held at this place were formerly frequented by merchants from distant parts of the country; and linen cloth, to a very considerable amount, was annually brought here for sale from all quarters of the country. These fairs, however, have now dwindled into petty markets for toys and sweetmeats. Adjoining the town are a mill for spinning flax, an iron-foundery, a brick and tile work, and a pottery for coarse earthen ware.—The population of Leven amounts to 1132; and its inhabitants are chiefly employed in the manufacture of coarse linen and sail cloth. (*h*)

LEVER. See MECHANICS.

LEW-CHEW ISLANDS. See LOO-CHOO *Islands*.

LEWES is a burgh and market town of England, in the county of Sussex. It is beautifully situated on a declivity, washed by the Ouse, and surrounded on every side, but the west, with an amphitheatre of high hills, which form part of the South Downs. The town is remarkably clean, and the streets, which are disposed irregularly, are in general spacious and well lighted. Lewes had formerly twelve parish churches, which are now reduced to six; namely, St. Peter's and St. Mary Westout, formerly two parishes, but now generally called St. Anne's; St. Michael in Foro, St. John sub Castro, All Saints, St. John Baptist South-over, and St. Thomas in the Cliffe. The most remarkable of these is St. John sub Castro, which is situated in the middle of the oval camp, and contains some curious inscriptions and monuments. St. John's South-over is a large church, close to the gate of the priory. St. Anne's, at the top of the High Street, is a new brick edifice, with stone rustic quoins, built on the site of the old church, which was taken down in 1805. St. Michael in Foro was rebuilt in 1755, and has a neat front, which is much admired. St. Thomas in the Cliffe is a very neat parish church, and has a particularly elegant altar. There are also seven meeting houses for the Presbyterians, Quakers, Arminian Methodists, General Baptists, Particular Baptists, and Calvinists.

The shire hall, erected in the High Street, is a new building, both elegant and commodious. The house of correction was built in 1794, on a plan recommended by Howard. It has thirty-two cells, a chapel, &c. The free grammar school was originally established in 1512. The theatre, which is a neat building, has lately been enlarged and improved. A library society was established here in 1786, and now possesses an excellent collection of books. The Sussex Agricultural Society, instituted in 1796, holds its meetings at Lewes: Its premiums are awarded about the beginning of August. On a hill, about a mile from the town, is a race course, reckoned one of the best in England. The races are generally held in the first week of August, and continue three days. The only manufacture of importance is at the iron-works, above the bridge, where cannon, shells, balls, &c. are cast. The river Ouse, which runs through the town below a handsome bridge, is navigable for barges six miles up the county, and enables the town to carry on a great trade in corn of all kinds and malt; and all the articles consumed in the adjoining county are imported at Newhaven, and sent up the Ouse to Lewes for sale. In consequence of the increase of its trade, two respectable banks have been established. The river Ouse was formerly navigable for small barges only from Newhaven bridge to Lewes, but since the passing of the act in 1791, it has been widened, deepened, and embanked, so as to be navigable for barges of a larger burden. The remains of the castle of Lewes are still in existence; and there is reason to think, that Lewes is the site of the Roman station called *Mantantonis*.

The population of the borough of Lewes, in 1811, was 6221. See *The Beauties of England and Wales*, vol. xiv. p. 126.

LEWIS is the name of the most northern, and the largest of the Hebrides, or the Western Islands of Scotland. It is connected with the Island of Harris, by a narrow isthmus on its southern side, which is entirely dry at low water, and not wholly covered at high water, so that the two may be considered as one island, although the Lewis part of it is politically connected with Ross-shire, while Harris belongs to Inverness-shire.

The whole island, including Harris, is 82 miles long, from the Butt of Lewis to the Sound of Bernera, extending north-west and south-east; and though it does not possess such numerous arms and indentations as the Island of Skye, yet it furnishes some of the best harbours in Great Britain. The average breadth of the island is 11 miles, and its area 451,000 Scots acres. Only about 26,000 acres are under regular meadow or corn land, the rest consisting of mountains, moors, marshes, and other wastes. The circumference of Lewis and Harris, following the sea mark, is 850 miles. The valued rent of the whole is 7783*l*. 6*s*. 6*d*. Scots, and the real actual rent, valuing kelp at 10*l.* per ton, is about 10,000*l.* Sterling per annum.

The island of Lewis is formed into four parishes, which compose the presbytery of Lewis, the parish of Harris belonging to the presbytery of Uist. These parishes are, Barras, Lochs, Stornoway, and Uig.

The parish of Barras occupies the northern extremity of the island, and is about 36 miles long, and 13 broad. It has about 45 miles of sea coast, which is bold and rugged, but contains no harbours for vessels, and only a few creeks where ships can enter in calm weather. The ground is level, but the soil is poor, moorish, and ill cultivated. Attached to this parish is the island of Rona, which is said to be the most north-western point of Europe, being situated 10 leagues to the N. W. of the Butt of Lewis. It is about a mile in length, and half a mile in breadth.

The parish of Lochs, so called from the number of its lochs or lakes, is about 19 miles long, and 9 miles broad at an average. Its line of coast, from its numerous inlets, amounts to 90 miles. The coast is bold and rocky. The soil is moory and unfit for culture, although by the industry of the inhabitants, and the use of sea-weed, some parts near the coasts have been cultivated. The inhabitants are principally employed in the fisheries, and in the manufacture of kelp, of which 50 tons used to be made annually. The Shaint or Holy Isles belong to this parish, and lie in the channel which separates Lewis and Skye. One of these is called *Haan Moair*, or St. Mary's Island, and has a chapel dedicated to the Virgin Mary. They are celebrated for pasturing sheep and black cattle.

The parish of Stornoway is very extensive; but the inhabited parts have the form of an isosceles triangle, two sides of which are 10 miles, and the other 7. The extent of sea-coast is 35 miles. The chief bays are Broad bay, South bay, Loch Stornoway, and Loch Grimshader, all of which afford excellent anchorage for the fishing vessels. In Loch Stornoway there is sufficient water for ships of any burden, and no heavy sea can come into it.

At the head of this bay, upon a projecting point, is built the town of Stornoway, which, by the exertions of the late Lord Seaforth, has, from being a paltry hamlet of a dozen of thatched houses, become the first town in the northern Hebrides.

The streets of this town are straight, and the houses neat and well built, and covered with slate. It has a commodious custom-house, a town-house, an assembly-room, and two convenient school houses, in which there were educated, in 1808, no fewer than 219 scholars of both sexes. Stornoway is a thriving town, possessing a brisk trade fishery. During the five years, ending July 1808, 17,430 barrels of cured herrings, and 719 tons of ling and cod fish, had been exported from the place, which had brought into the town at least 52,000*l.* The quantity of oil exported during the same period amounted to about 10,000*l.* In 1808 there were about 44 registered vessels, of from 16 to 127 tons burden, belonging to the port and district, which were navigated by 136 men and boys, and of which the tonnage amounted to 1612 tons. In addition to those which were regularly employed in fishing and in trade, there were 104 small boats, navigated by 562 men, and occasionally engaged in the herring, ling, and cod fishery. These boats did not all belong to Stornoway, but they had their residence there for part of the year, and contributed to enrich the place. The population of Stornoway, in 1808, was 2305. Seaforth Lodge, the residence of the late Lord Seaforth, stands in an elevated situation, near the town.

The parish of Uig is about 15 miles long, exclusive of the wide entry of Loch Roag, and 13 miles broad. It has about 60 miles of coast, and everywhere affords safe harbours for ships of all sizes. The coasts alone are level and cultivated, and the interior is hilly, and covered with heath and lakes. Loch Roag is a large arm of the sea, about 7 miles broad, and 19 long. It contains several islands, the principal of which are the Great and the Little Bernera, the former being 12 miles long, and 4 broad, and the other 4 miles long, and 1 broad. This arm of the sea contains the finest anchorages, and abounds with immense quantities of fish of all kinds.

Harris (which, with its smaller islands, is politically attached to Inverness-shire) is divided from the Lewis part of it by two bays, called Loch Resort, on the west, and Loch Seaforth, on the east, having between them an isthmus of about six miles over. Harris is 25 miles in length, from north to south, and very various in breadth. It is almost bisected at Tarbert by two arms of the sea, called East and West Tarbert, where the isthmus is about a quarter of a mile broad. The country lying to the north, between it and Lewis, is a deer forest, and consists of an accumulation of peaked and rocky mountains, of the wildest and most fantastic character. The district to the south of Tarbert is also hilly and rocky, with the exception of a narrow stripe of plain, running along the west coast, where the hills also are green. There are on this side two large tracks of sand, one four miles in circumference, and the other one and a half mile long, by one mile broad, both of them capable of being recovered from the sea. The east coast of Harris is singularly indented all along with innumerable bays, creeks, and natural harbours, and presents a frightfully rocky and barren appearance when viewed from the sea. The neighbourhood of the shore, however, is inhabited all along; and near the little settlements are patches of barley, oats, and potatoes, raised by extreme labour. The intermediate space is a wild and uncultivated common.

The smaller islands attached to Harris, may be divided into the north and south isles. Of the northern isles, there are three inhabited. Taransay is high and rocky; four miles long, and one mile broad. Scalpay, lying in the entrance to East Loch Tarbert, is low, heathy, round, and about three miles wide; but is much intersected by arms of the sea. It has a light-house on it, and at the western extremity two of the best natural harbours in the Hebrides. Scarp, situated in the mouth of Loch Resort, is one entire mountain of rock, about three miles in diameter. The uninhabited islands belonging to this division are numerous; the largest are, Skeotisvay, about a mile long; Isay, long and flat; the two Soays; Fladday; and a large green island called Gaskeer, frequented by geese. Of the southern isles of Harris, four are inhabited, Berneray, Pabbay, Calligray, and Ensay. Berneray, lying about a mile north of Uist, is four miles long, and one and a half broad, and very fertile; but its north-west side is injured by the breaking up and blowing of sand banks. (For an account of the remarkable tides in the vicinity of this island, see the article BERNERAY.) Pabbay, about two and an half miles in diameter, lies about a league north-west of Berneray; it rises to a peak in the centre, higher than any part of the other islands in the sound. It was once considered as the granary of Harris; but the sand drift has destroyed much of its fertility, and gives it a desolate appearance on its south-east side: the south-west side is still verdant, and cultivated. Calligray and Ensay lie about a league and a half east from Berneray, being separated from each other by a narrow sound called Caolas Scaire, through which the tide passes with the most impetuous current known upon these coasts. The sea in which these islands are situated is called the Sound of Harris, and is much frequented by shipping. Calligray is two miles long, and one broad, having a deep moss at the south end, and a cultivated sandy soil at the northern extremity. Ensay, is nearly the same shape as Calligray, and is verdant and cultivated all over. The names of the largest uninhabited islands of this division are, Hermitray, Hulmitray, Saartay, Votersay, Neartay, Opsay, Vaaksay, Haay, Suursay, Torogay, Scarvay, Lingay, Groay, Gilisay, Sogay, Stromay, Skeilay, and Copay. Besides these there are a number of islets and high rocks; and as all the larger islands end is *ay*, it is remarkable that all these smaller ones end in *em*, as Tuem, Cuadem, Coddem, &c. Gaelic is the universal language.

The great body of Lewis and Harris is uninhabited. The straggling hamlets of the natives are found only within half a mile of the coast, and there is scarcely an inhabited dwelling more than 1000 yards from salt water.

The population of Lewis and Harris, according to the census of 1811, was 13,661.

The art of cultivation is very far back in these islands. Ploughs are rarely used, and where used, the implement is the common Scotch one, with a feathered sock, drawn by four miserable horses. The soil near the shore is in general sandy, being covered by the particles (chiefly of finely ground shells,) drifted from the heaps by high winds. Towards the rising grounds, the soil is a mixture of black earth and sand, formed from the decomposition of granite; both these produce rich crops of Scotch barley, or bear, when manured. The greater part of the soil is moss upon clay and gravel. Sea-weeds in great quantities are drifted upon the sheltered parts of the coast, and constitute 4-5ths of the manure used by the natives. The remainder is produced by an indescribable species of domestic economy. The chief crops are oats, barley, flax, and potatoes. There was no hemp grown in 1808. From the sharpness of the soil, and the heat of the summer months, the harvest is generally very early. It is not uncommon to cut barley the first week of August, and within nine weeks after the seed has been sown. The quantity of grain raised is sufficient for the consumption of the islands, in spite of distillation and mismanagement. Where the plough is not used, lazy beds are formed, and the surface being thickly laid over with sea-weed, generally carried to the place on the farmer's back, it is closely covered with sod, cut with a particular species of spade: the bed is then left until late in the spring, when the clods are pulverized with a heavy kind of hoe, and the ground sown with barley, or planted with potatoes, the whole being afterwards harrowed with a hand-rake, having six timber teeth, and a handle two feet long. The women and children assist in these operations. When the barley is ripe, it is generally plucked up by the roots, and tied into sheaves; and the stubble is so valuable as thatch, that it is afterwards cut off with a sickle, and the barley built up in stacks. On every farm there is a kiln for drying the corn; the principal tenants have also each a mill of a simple construction; but in general the meal is made by means of the *quairn*, an instrument in use formerly all over Scotland. This is formed by a couple of stones, the lower one hollow, and the upper made to fit easily into the cavity, so as to be turned by a staff or handle fixed in it. The home grown meal is generally consumed before the month of June; and those who cannot afford to buy imported meal, subsist on the milk of their sheep or cows, or upon fish, or on the root of the *potentilla anserina*, until the potatoe crop is ready for use. Mr. Macdonald considers these islands as the most backward in agriculture, and in the general state of the inhabitants, of all the Western Isles.

Cattle and kelp are the chief saleable articles of produce. The kelp manufacture has been lately prosecuted with ardour. About 140 tons of a superior quality are annually made from Loch Roag, and about 50 tons in the parish of Lochs. The cows are much poorer and smaller than those of the island of Skye; but they make very delicate beef, when exported and fed on good pasture. The parish of Lochs contained in 1795, 2488 cattle, 4000 sheep, and 348 horses. The parish of Stornoway contained 2440 cattle, 2576 sheep, and 556 horses; and the parish of Uig contained, 3562 cattle, 5044 sheep, 682 horses, and 304 goats. Harris and its islands contain about 900 milk cows; and about 200 head of cattle are generally sold annually to drovers. The whole stock of cattle in Harris and its islets may be about 2500. The sheep in Harris are of a diminutive size, of a thin lank shape, with straight horns, the face and legs white, tail short, and wool sometimes bluish-grey, sometimes black, brown, russet, or blotched of various colours: their number is about 1100. On Harris a considerable tract of ground has been stocked with Tweeddale or black faced sheep, by Mr. Mackinnon of Corry, and other gentlemen. In some of the mountainous islands, they are said to have sometimes four and sometimes even six horns. The number of goats is trifling. There are not less than 1000 horses in Harris, of a very small size, but remarkably stout and hardy. Some of the gentlemen have larger horses on their farms, and a few asses have been introduced. Fowls and fish of every kind are abundant.

There are many Druidical circles in these islands, and numerous Danish signal forts; and most of the proper names of the islands, &c. are of Danish origin. Near the small village of Colarnish in Uig there is an entire Druidical circle, consisting of 12 stones, each about 7 feet high, and 6 feet distant. In the centre is an obelisk of a larger size, 13 feet above the ground. Three obelisks stand directly south from the circles, running out in a line, another due west, and another east; towards the north there are two straight ranges of obelisks, reaching by way of avenue to an opening between two of the stones of the circle. Each of these ranges consist of 6 stones regularly placed. At Melish in Uig are the remains of a nunnery, called "the house of the old black women." There is a Danish fort, or Dun of Cailaway, which is probably the most entire in Scotland. The form is perfectly circular, and it has a double wall of dry stone 30 feet high.

Harris is a parish in the presbytery of Uist. There are seven stated places for public worship according to the church of Scotland, in the parish of Harris; two of these are no less than thirty-six miles asunder: the clergyman has a missionary assistant. There are two churches of stone, with slated roofs.

The climate is, as may be naturally supposed, variable and moist. The springs are very cold, the summers warm, the autumn attended with heavy rains, and the winters are stormy and cold, but without long or severe frosts, or heavy falls of snow. These islands, however, are differently constructed from the continent of Great Britain; the high ridge running throughout their length being close to the east coast, and the west coast being comparatively flat.

Of the mineralogy of Harris, we believe, little is as yet known. There seems, however, to be neither limestone nor freestone in the country; and from all accounts, granite appears to be the common rock. There are some appearances of copper and iron, and there is a number of chalybeate springs.

The deer (*Cervus elaphus*) in the forest amount to perhaps 800 head. Some of the uninhabited islands abound with rabbits (*Lepus cuniculus.*) Of wild birds, there are grouse, (*Tetrao attagen*,) ptarmigan, (*Tetrao lagopus*,) woodcocks, (*Scolopax rusticula*,) snipe, (*Scolopax gallinago*,) and plovers, (*tringæ*,) of various kinds; also eagles and hawks, (*falco*, &c.) crows, (*Corvus corone*, &c.) teals, (*Anas crecca*) curlews, *Scolopax arquata*,) bernicles, (*Anas bernicla*,) wild geese, (*Anas anser.*) gannets, (*Pelicanus bassanus*,) cormorants, (*Pelicanus carbo*,) and scarts, (*Pelicanus gracchus*,) with innumerable other sea-fowls. The numerous fresh water lakes and streams abound with excellent black trouts, (*Salmo fario*,) and a few salmon, (*Salmo salax*,) frequent the mouths of the rivulets in the spawning season. The basking shark, or sail fish, (*Squalus maximus*,) is frequently killed in May and June; they are from 25 to 40 feet in length, and the liver of a large one produces eight barrels of oil. Seals (*Phoca barbata et vitulina*) are very numerous at all seasons. The sea-fish most plentiful are the herring, (*Clupea harengus*,) dog-fish, (*Squalus canicula*,) cod, (*Gadus morhua*,) ling, (*Gadus molva*,) skate, (*Raia batis*,) mackarel, (*Scomber scomber*,) cuddy, (?) and sand eel, (*Ammodytes tobianus.*) There are also abundance of shell fish, and the dredging for oysters, (*ostreæ*,) and the taking of lobsters, (*Cancer gammarus*,) might be a valuable increase of revenue to the inhabitants; but they are ignorant of the secret of catching them, and this natural advantage is carried off from them by expert fishermen, who come to load their little vessels for the London market.

Lewis and Harris were certainly once covered over with trees, if we may judge from the remains found in mosses; but there is now no such thing in the whole district; and even the bushes and shrubs, which gentlemen have attempted to plant in their gardens, die, as soon as they rise higher than the wall. The list of cryptogamous plants, particularly of *Fuci* and *Algæ*, would undoubtedly be found to be extensive, if the shores were accurately examined; but, in other respects, the flora of Harris is very meagre. See Martin's *Description of the Western Islands of Scotland;* Buchanan's *Travels in the Western Islands;* but particularly M'Donald's *Agricultural Survey of the Hebrides.*

LEXELL, ANDREW, JOHN, an eminent mathematician and astronomer, was born at Abo in Finland, on the 24th of December, 1740. He went through his early studies in that town, and applied himself eagerly to the abstract sciences. In 1760, he took his degree of doctor in philosophy, and published an inaugural dissertation, entitled *Aphorismi Mathematico-Physici*, after having disputed under the presidency of M. J. Gadolina, professor of natural philosophy.

In 1763, M. Lexell repaired to Upsal, where he distinguished himself by a disputation, entitled *De Methodo inveniendi lineas curvas ex datis rudiorvm osculi proprietatibus*, which obtained for him the situation of lecturer in mathematics; and such was his reputation, that, in 1766, he was appointed professor to the corps of marine cadets.

In consequence of the arrival of Leonard Euler at St. Petersburgh, and the preparations which were making, in 1769, to observe the transit of Venus in eight different parts of the Russian empire, M. Lexell became anxious to reside in a capital containing such attractions for men of science, and where genius and industry never failed to meet with their reward. With this view, he had sent to the academy, in 1768, a memoir on the the integral calculus, entitled, *Methodus integrandi nonnullis æquationum exemplis illustrata.* Euler was charged with the examination of this memoir, and gave a very favourable report upon it. The Count Wolodimer Orloff, however, who was then director of the academy, stated his suspicion that it might be the work of some able geometer, who wished to favour Lexell by his assistance; to which Euler replied, that if this were the case, it must have been written either by D'Alembert or himself, and that Lexell was unknown to both.

The Count, satisfied with this high eulogium on the merits of Lexell, did not hesitate a moment in sending to him an appointment of adjunct in the Academy for the Mathematical Sciences. Lexell eagerly accepted of the situation; and on the 17th of October, 1768, he obtained the consent of the Swedish government, and set off without delay for St. Petersburgh. Upon his arrival in that capital, he began to make himself familiar with the use of astronomical instruments, in order that he might be able to observe with success the transit of Venus; a duty which he performed to the satisfaction of the academy, along with Father Meyer, who had been appointed, along with him, to attend the observatory during the absence of the astronomers. M. Lexell became very intimate with Euler, who employed him in writing out all the calculations and memoirs with which he was occupied. Lexell had also a considerable share in the new theory of the moon, and in the determination of the sun's parallax, as deduced from the observations of the transit of Venus, which are published in the 14th volume of the New Commentaries of St. Petersburgh.

The reputation of M. Lexell now increased every day. In 1771, he was received among the number of ordinary academicians, and Count Orloff gave him the place of one of the astronomers. The academies of Stockholm and Upsal elected him a member of their body, in 1773 and 1774; and the Royal Academy of Sciences of Paris sent him the diploma of corresponding member, in 1776. In 1775, the King of Sweden conferred upon him the situation of professor of mathematics in the university of Abo, with permission to remain three years at St. Petersburgh; a period which was twice prolonged for a year, till 1750. M. Lexell was now upon the eve of quitting St. Petersburgh, and of settling himself in his native town; and the academy would soon have lost his talents, had not M. de Domaschnef offered him leave to undertake a literary voyage through Germany, France, and England, and to return by Sweden to St. Petersburgh. M. Lexell undertook the task, and returned to St. Petersburgh in the course of a year, (in 1781,) highly satisfied with his journey.

In 1733, the Princess Daschkaw gave him the place in the academy which had been vacated by the death of Euler, and besides added considerably to his appointments. The Royal Academy of Sciences of Turin received him in the same year among the number of its foreign associates; and the English Board of Longitude, in 1784, put his name in the list of philosophers, to whom they sent all the works which they published relative to the determination of the longitude at sea. M. Lexell, however, did not live long to enjoy these honours He was seized with an illness before the winter of 1784, and died on the 30th of November of that year, in the 40th year of his age, of a gangrenous tumour, followed by a malignant fever.

Besides the works we have mentioned, M. Lexell published, in the Philosophical Transactions for 1775, a paper on the occultation of stars, and on two curious theorems respecting polygons, which were communicated in a letter to Dr. Morton. In the same work for 1777, he published a paper "On the Periodic Time of the Comet of 1770," which he stated at 5½ years.

When the Georgium Sidus was discovered, he set himself eagerly to observe its motions; and, in 1782, he publisned at St. Petersburgh a small work, entitled *Recherches sur la Nouvelle Planete*, where he attempted to compute its motions, upon the supposition that it moved in an orbit nearly circular; and he has shewn, that a circular orbit, whose radius is about nineteen times the distance of the earth from the sun, will nearly represent all the observations made in 1781. His papers in the Memoirs of the Academy of St. Petersburgh, between 1768 and 1784, amount to about fifty-six. They are principally on mathematical and astronomical subjects.

LEYDEN, the *Lugdunum Batavorum* of Ptolemy, is a town of Holland, and next in importance and population to Amsterdam. It is situated on the ancient bed of the Rhine, which divides the town into a number of islands, connected by bridges, which amount to nearly 100. The principal street, which is reckoned one of the finest in Europe, is built in the form of a crescent. The most important public buildings are, the church of St. Peter, and the town-house. The church is esteemed one of the handsomest in Holland. It contains the tomb of the great Boerhaave, with the simple inscription of *Salutifero Boerhavii genio sacrum*, and also the tombs of P. Camper and Meerman. The town-house has many spires, and is a handsome building, with a stone front. A very capital painting of the last judgment, by Lucas of Leyden, is preserved in the burgomasters' chamber. The other public buildings are the observatory, and the chateau, which commands a magnificent view. The subterraneous sewers of Leyden are ranked among the curiosities of the place. One of them is about a quarter of a league long, and receives the boats, for the purpose of cleaning them.

The university was founded in 1575, by William, Prince of Orange; but it has no building of importance, as the professors live in private houses, and the students in lodgings. The library is open only once a week, and contains about 40,000 volumes. The salaries of professors, exclusive of fees, is about £200 per annum. There is also in the university a physical cabinet and a museum of natural history. There is a literary society at Leyden, and also a poetical society.

Leyden possesses some good private collections and cabinets, &c. The principal of these are, M. Doeveren's cabinet of antiquities and collection of minerals; the cabinet of natural history of M. François Berkley; the botanic garden; the anatomical collections of Doeveren, Rau, and Albinus; the cabinet of paintings of M. Selfos; the collection of prints of M. de Leyde, which was reckoned the best in Holland; M. Tak's collection of Dutch paintings; and M. Dibbel's cabinet of designs and medals.

Leyden has eight gates, and its ramparts, which form an excellent promenade, are formed of earth, partly covered with turf, and partly faced with brick, and consisting of several bastions.

Leyden has long been celebrated for its manufacture of cloth, and there is a staple hall erected for the use of the manufacturers and merchants. There are also manufactories of soap and indigo. The fair of Leyden is still much frequented. Its booths arranged under trees, and along the banks of the canals, occupy about one-fourth part of the town. East Long. 4° 29′ 13″ N Lat. 52° 9′ 30″. Population 30.955.

LEYDEN Phial. See Electricity.

LEYDEN, John, an eminent poet and oriental scholar, was born on the 8th of September, 1775, at Denholm, a village of Scotland between Jedburgh and Hawick, in the county of Roxburgh. Although our author was nearly ten years of age before he had an opportunity of attending even the reading school, and received the whole of his early education under very unfavourable circumstances, yet he made rapid progress in his studies; and overcame, by his own persevering exertions difficulties which would have discouraged a less ardent and ambitious character. His parents having determined to educate him for the Scottish church, he was instructed in the Latin language by Mr. Duncan, a Cameronian minister at Denholm, and was reckoned fit to enter the college of Edinburgh in the year 1790. Here he was soon distinguished by a profound knowledge of the Greek and Latin languages; and while he attended to the various sciences which a candidate for the church is compelled to study, his leisure hours were employed in acquiring a knowledge of the French, Italian, Spanish, and German languages, to which he joined a familiar acquaintance with the ancient Islandic, the Hebrew, the Arabic, and the Persian.

In the year 1798, he attended two young gentlemen who were studying at the college of St. Andrew's; a circumstance which secured him the acquaintance of Professor Hunter, an excellent classical scholar and philologist, to whose instructions Leyden acknowledged himself deeply indebted. About this time, the expedition of Mungo Park, who had been the early friend and college companion of Leyden, had excited universal notice, and naturally turned the attention of Leyden to the history of Africa; a subject which he studied with much attention. His researches were published in 1799, in a small volume, entitled *A Historical and Philosophical Sketch of the Discoveries and Settlements of the Europeans in Northern and Western Africa, at the close of the* 18*th century*, a new edition of which has lately been published.

In the winter of 1799 and 1800, Mr. Leyden became acquainted by accident with Mr. Richard Heber, by whom he was introduced to some of the principal families in Edinburgh, and particularly to that of Mr. Walter Scott, who was then beginning to display that fine genius, and those splendid talents, which have placed him at the head of the literature of Europe. In this society, the excellence of Leyden's disposition, and the depth of his knowledge, atoned for those unfortunate peculiarities of manner, which can be tolerated only when they are the accompaniments of genius.

In 1800, Leyden received his license as a preacher of the gospel, and he preached in several of the churches of Edinburgh and its neighbourhood. In the autumn of the same year, he accompanied two young foreigners in a tour to the Hebrides, where he studied the traditions and manners of the Highlanders; and it is a curious circumstance, that after a long and painful investigation of the Ossianic controversy, he adopted an opinion in favour of the authenticity of the poems. He composed several detached poems on the Highland traditions which he had collected; and when he passed through Aberdeen, he obtained from Dr. Beattie a transscript from the only existing copy of the poem entitled Albania. This poem is a panegyric on Scotland, in blank verse, written about the beginning of the 18th century, by an anonymous author. It was afterwards published by Mr. Leyden, along with Wilson's "Clyde," in a volume entitled *Scottish Descriptive Poems*, which appeared in 1802.

In the year 1801, Leyden contributed the ballad called the Elf-King to Lewis' *Tales of Wonder;* and in 1802, he was diligently employed in procuring materials for the *Minstrelsy of the Scottish Border*, the first work of Mr. Walter Scott. To this interesting publication Leyden contributed the ballads entitled Lord Soulis and the Count of Keeldar; and though Mr. Scott arranged and digested the Dissertation on Fairy Superstition, yet it was originally compiled by Leyden, and "abounds with instances of such curious reading as Leyden alone had read."

The next work of Leyden was a new edition of *The Complaynt of Scotland*, a very scarce tract, written about the year 1548. It was published in 1801, and accompanied with a dissertation, notes, and glossary, which displayed an intimate acquaintance with Scottish antiquities, and an extent of research, and power of arrangement, which has seldom been equalled.

In the year 1802, when the Edinburgh and Scots Magazine were united, Leyden undertook to edite it, and discharged this duty for about five months. In the same year he began his poem entitled *Scenes of Infancy*, "in which he has interwoven his own early feelings and recollections with the description of the traditional history of his native vale of Teviot." It was not published, however, till the year 1803.

Mr. Leyden was now in the 27th year of his age, but without any immediate prospect of a settlement for life. His friends were therefore anxious to turn his passion for knowledge to some account, and the more so, as he had actually made overtures, in 1802, to the African Society, for undertaking a journey of discovery through that continent. The peculiar talents of Leyden were therefore stated to the Right Honourable W. Dundas, who had then a seat at the Board of Controul; and it was suggested, that they might be advantageously employed in investigating the languages and literature of India. Mr. Dundas entered eagerly into this plan; but the only appointment at his disposal was that of surgeon assistant, which could be held only by a person who had received a surgical diploma, and could pass an examination before the medical board at the India House. Leyden eagerly accepted of the appointment, with the understanding, that he was to be employed only in literary researches when he arrived in India; and he actually succeeded in qualifying himself for it in the space of five or six months. He received a diploma from the College of Surgeons of Edinburgh, and obtained a degree of M. D. from the University of St. Andrews. About the middle of December 1802, he left Edinburgh, to join the fleet which was on the eve of sailing for India. On his journey to London he was seized with the cramp in his stomach, in consequence of his excessive exertions in Scotland; and when he arrived at the India House under the influence of this disorder, he was told that he must either proceed to the Downs, or vacate his appointment. The clerks made out his appointment, and orders to sail in the Hindostan, as if he had been in perfect health; and had it not been for the kind interference of Mr. George Ellis, the author of the Specimens of ancient English Poetry, he would have been drowned in the Hindostan, which was actually wrecked in going down the river. By Mr. Ellis's influence, he got permission to go in the Hugh Inglis to Madras,—a circumstance which allowed him to reside in London till the beginning of April 1803. The Hugh Inglis set sail on the beginning of April, and after a voyage distinguished principally by a mutiny in the vessel, in which Leyden evinced great intrepidity, he arrived at Madras, where he was nominated surgeon to the commissioners appointed to survey the ceded districts; and was at the same time directed to carry on inquiries concerning the natural history of the country, and the manners and languages of the natives of Mysore. His health, however, was unable to resist the effects of the climate, and his unwearied exertions to acquire the languages of the Mysore; and, as appears from his "Address to an Indian gold coin," his health and his spirits were so much injured, that he was obliged to leave the presidency of Madras, and repair to Prince of Wales's Island. Previous to his leaving Madras, he succeeded in translating the famous Jewish tablets of brass, preserved in the synagogue of Cochin, and which had puzzled all preceding orientalists. He had studied the Arabic, Persic, Hindostani, Mahratta, Tamul, Telinga, Canara, Sanscrit, Malayalam, Malay, and Armenian languages; and he had decyphered the inscriptions of Mavalipoorani, written in an ancient Canara character, and also several *Lada Lippi* inscriptions, which is an ancient Tamal dialect and character.

During his voyage from Travancore to Pulo Penang, or Prince of Wales's Island, which was performed in a Mapilla brig, it was chased by a French privateer, which led Dr. Leyden to compose an *Ode to a Malay Cris*, or dagger, the only weapon which the state of his health permitted him to use. In this island Dr. Leyden found many friends, and enjoyed the confidence of Philip Dundas, Esq. who was governor of the island. During his residence in that place, he visited Achi and some other places on the coast of Sumatra, and the Malayan peninsula; and he collected the curious information respecting the language, literature, and descent of the Indi-Chinese tribes, which is given in the valuable dissertation on that subject, which he laid before the Asiatic Society.

In 1806, he left Pulo-Penang, and arrived at Calcutta, where he was warmly patronised by Lord Minto, who was peculiarly qualified to appreciate the talents of his distinguished countryman. Dr. Leyden was at first appointed a professor in the college of Bengal; but that appointment was soon afterwards exchanged for that of a judge of the twenty-four pergunnahs of Calcutta, an office from which he received a very considerable yearly income. Excepting the part of that income, which was remitted to Europe for the best of purposes, the rest was spent in promoting the objects with which his whole mind was occupied.

In 1811, Dr. Leyden accompanied Lord Minto in the expedition to Java, with the view not only of investigating the manners, language, and literature of the various tribes of that island; but also for the purpose of assisting in settling the government of the country, or in communicating with the independent princes in the neighbourhood of the Dutch settlements. When they reached the island, he had the rashness, along with another volunteer who accompanied the expedition, to throw himself into the surf, in order to be the first Briton in the expedition who should set foot on Java. After the town of Batavia surrendered to our troops, Dr. Leyden exhibited the same ridiculous want of regard to his health, in his hurry to examine a library in that city, where many valuable Indian MSS. were said to be deposited. He accordingly went into an apartment supposed to have been ill ventilated, and when he left it he was seized with a fit of shivering, which led him to remark, that the atmosphere was enough to give any mortal a fever. His illness increased, and in three days he was carried off in 1811, in the 36th year of his age, and on the very day when the island of Java surrendered to the British arms.

The literary remains of Dr. Leyden were committed by his last will to the charge of Mr. Heber, and Dr. Hare of Calcutta, but they have not yet been given to the public. For the preceding particulars of Dr. Leyden', life, we have been indebted to a very interesting biographical memoir of him, which appeared in the *Edinburgh Annual Register* for 1811, and which seems to have been written by his distinguished friend Mr. Scott.

LIBAU, or **Liebau**, is a sea-port town of the duchy of Courland, situated on the Baltic, and built by the Lettonians. It is a large, open, and indifferently built trading town, consisting chiefly of wooden houses. Its harbour, which was cleared in 1737 by Ernest John, is now very commodious for light vessels. The harbour never freezes up in winter, but it has only from 10 to 11 feet of water, depending on the wind, so that large vessels must discharge in the roads, which is obtained at considerable expense, and some risk. The principal exports and imports are,

Exports.	Imports.
Wheat.	Fustic logwood.
Rye	Coffee.
Barley.	Cotton.
Pease.	Ginger.
Crushing linseed.	Pepper.
Hempseed.	Pimento.
Oats.	Rice.
Bristles.	Sugar of all kinds.
Goose feathers.	Molasses.
Flax.	Salt.
Hemp.	Herrings.
Codilla.	Cochineal.
Iron.	Indigo.
Tallow.	Twist.
Wax.	Wire.
Buck skins.	
Calf skins.	
Goat skins.	
Horse hides.	
Ox and cow hides.	
Sheep skins.	
Sail cloth.	
Ravenduck.	

The wheat is superior to that from the Russian ports, and is commonly kiln-dried. The other grains are sent chiefly to Holland, Spain, and Portugal. Flax, which is of an inferior quality, comes principally from Lithuania. The hemp is like the pass-hemp of Riga. Hides and skins are both cheap and good at Libau. The merchants store it in vaults till it is purchased by the country people, who bring supplies of Russian produce.

The annual exports of Libau, are,

Rye	10,000 lasts.
Wheat	2,000 ditto.
Barley, &c.	4,000 ditto.
Oats	2,000 ditto.
Flax	15,000 poods.
Hemp	17,000 ditto.
Crushing linseed . .	1,000 barrels.
Sowing linseed . .	10,000 ditto.
Hides and skins . .	18,000 decker.

In the year 1800, there arrived at Libau 117 vessels, and there set out 111. The value of the exports had been 1,065,699 rubles, and that of the exports, 620.537. North Lat. 56° 31′ 36″, and East Long. 20° 55′ 20″. See Catteau de Calleville's *Tableau de la Mer Baltique*, tom. ii. p. 305. Paris 1812; and Rordansz's *European Commerce*.

LIBEL. See Law.

LIBRARY. The obvious advantage of preserving written language led to the formation of books, any considerable assemblage of which constitutes a library. At the period of the Spanish invasion, emblems or pictures were employed by the South American nations instead of writing, for they were unacquainted with letters; but in Yucatan and Honduras, there were books made of the leaves of trees; and "in the province of Mexico they had a *library*, histories, and calendars, wherein they painted such things as had proper figures, in their natural representations, and such as had none, with other characters, and thus they represented whatever they pleased." *Herrara*, Decade ii. Book ix. ch. 4. This must be considered as a library in its earliest stage; for all which are described to have belonged to the ancients were composed of books, or rolls, resembling those of the moderns.

Annexed to the edifice forming the sepulchre of Osymanduas, one of the ancient kings of Egypt, was a library, inscribed with these words, "Food for the mind," and sculptures on the walls represented "a judge, with the image of truth hanging from his neck, and many books lying before him." *Diodorus Siculus*, lib. i. cap. ii. One of the most celebrated libraries in the world was founded at Alexandria, 283 years anterior to the Christian æra, by Ptolemy Philadelphus, who obtained for it the books belonging to Aristotle, first bequeathed by that philosopher to Theophrastus: and here also the version of the Septuagint was preserved. No expence was spared on the collection, which at length amounted to 500,000 volumes, according to Josephus, or 700,000, according to Aulus Gellius and Ammianus Marcellinus; but after subsisting 244 years, it was burnt accidentally during the expedition of Cæsar to Egypt, though the ancients disagree as to the precise cause of the conflagration. Seneca affirms that the Alexandrian library was rather to be considered a pompous spectacle for the public than a place for the studies of the learned: *De tranquillitate animi*, cap. 9. Another library was collected at Alexandria, which was partly extant in the time of Tertullian, and one of great extent is said to have been burnt by the Mahometans in the year 641 or 650, by the Caliph Omar.

A library is supposed to have been kept in the temple of Jerusalem; and the Jewish authors speak of "the multitude of books."

In scripture, it is written, that a search was made "in the house of the rolls, where the treasures were laid up in Babylon," for a decree by Cyrus to build a temple at Jerusalem; but it was found at Achmetha in Media: *Ezra*, ch. v. 17. vi. 1, 2. It does not appear to us, as to some authors, that the house of the rolls was a library belonging to the Persians, or any thing else than the archives of the kingdom.

Pisistratus founded a public library in Athens, which was carried to Persia by Xerxes, and brought back by Seleucus Nicanor, plundered by Sylla, and restored by Hadrian. Eumenes the son of Attalus collected a library of 200,000 volumes at Pergamus, according to Strabo and Plutarch, which the latter says, Calvisius, a retainer of Cæsar's, accused Mark Antony of having given to Cleopatra: *In Vit. Anton.*

Many authors have written concerning the libraries of Greece, and various conjectures have been formed where the remains of the ancient historians may be expected still to exist: The subject has been renewed lately by the Rev. Mr. Walpole, in the following observations published in Dr. Clarke's *Travels*:

"As many manuscripts had been collected, at vast expence, in Greece for the library at Buda, (destroyed by the Turks in 1256,) we ought not to omit mentioning it. Alexander Brassicanus had seen in it the whole of *Hyperides* with *Scholia*, the works of many of the Greek fathers, and of the classical writers. From this library issued parts of *Polybius* and *Diodorus Siculus*. A manuscript of *Heliodorus*, from which was taken the first edition of the *Æthiopics*, was found by a soldier, and brought to Vincentius Obsopæus: it belonged to this library. Neander thus speaks of the collection: 'Ex mediâ Græciâ inæstimandis sumptibus emerat Matthias Corvinus rex.' *Epist*. p. 10.

"There is no doubt that Constantinople and Athos have contributed the greatest number of the manuscripts we possess in different parts of Europe. There were monasteries full of learned men at Byzantium, to a late period; and every monastery had its library. The Turks, on their conquest, did not occasion that indiscriminate destruction which idle declamation has sometimes imputed to them. Mahomet the Second secured the library of the Greek Emperors, which was preserved by his successors, until it was destroyed by Amurat IV. At Byzantium, Constantine Lascaris transcribed many of those works which were afterwards placed in the Madrid Library. In this city were procured those manuscripts which were left to the Escurial Library by Hurtado de Mendoza, and which had been presented to him by Soliman the Second. Possevin has given partial catalogues of some of the libraries at Constantinople; and a traveller, in 1597, mentions a valuable collection which he had seen in that city.

"With respect to Athos, we find that two hundred manuscripts are deposited in one library alone, brought from the monasteries on the mountain; and a great part of those at Moscow had been collected by the monk Arsenius, in Athos, at the suggestion of the Patriarch Nicon.

"We must add Thessaly, Chios, Corfu, Crete, Cyprus, Chalce, (the island in the Propontis,) Rhodes, and Epidauria, as places which have supplied some manuscripts. We should have had much valuable intelligence concerning the libraries in the monasteries of Thessaly, if the life of Professor Biornstahl had been prolonged. He had visited all of them, and had resided many days at Triccala, for the express purpose of copying a Greek manuscript belonging to a monastery. Biornstahl was attacked by a fever at the foot of Mount Olympus: here he was obliged to continue ten days, without medical assistance, and was then taken to Salonica, where he died, in July 1779.

"Notwithstanding our acquisitions are already great, we should not intermit our researches in the Levant. Many manuscripts may be saved by them from destruction. 'I myself,' says Dr. Covell, 'have seen vast heaps of manuscripts (for I never found them on shelves, or in good order) of the Fathers and other learned authors, in the monasteries at Mount Athos, and elsewhere, all covered over with dust and dirt, and many of them rotted and spoiled.' An inquiry should be made into the truth of what was stated to Hemsterhusius by some Greeks, 'that part of the Comedies of Menander was still in existence. Application might be made to the Greek nobles of the Phanar, many of whom are versed in ancient Greek, and who are probably the possessors of some valuable manuscripts. Parts of the first book of the *Demonstratio Evangelica* of Eusebius were printed by Fabricius from a manuscript belonging to Prince Mavrocordato; and a copy of the Greek Orators, now in England, was the property of a Greek noble.

"It may be reasonably supposed, that many manuscripts in Greece have experienced the treatment which works of the same sort have met with in other countries. Poggius, we are told, found, while he was at the Council of Constance, a manuscript of Quintilian, on the table of a pickling shop. Masson met with one of Agobardus in the hands of a bookbinder, who was about to use it for the back of a book; and one of Asconius was about to be employed for the same purpose. Musculus found, in the roof of a Benedictine monastery, some of the works of Cicero, and the whole of Ovid. Numbers of manuscripts in Greece are irrecoverably lost to us, either by design or accident; and of those, which we may hereafter meet with, we cannot suppose all will prove to be of equal value:

Πολλοί τοι ναρθηκόφοροι παυροὶ δέ τε βακχοι.

Yet if we meet with only few of which we shall be able to say, as Casaubon once said to J. Scaliger, that they are '*πολυτιμητὰ*, et verè *χρυσοῦ ἀνταξία*,' the trouble of research will be well requited.

"A list of theological manuscripts in the Library of Patmos, has been given by Possevin; their number amounting, according to his statement, only to fifty-five. The present catalogue, containing the titles of ninety-two manuscripts, and about four hundred printed volumes, and of which an account is here subjoined, by no means precludes the necessity of further examination. The Greek compiler of it has not stated any circumstance relating to the manuscripts, by which we can form an estimate of their value: he gives no information respecting the form of the letters, or that of the spirits, or any of those subjects which would lead us to a knowledge of their respective dates.

"There is one manuscript mentioned in it, concerning which it is impossible not to feel more than common curiosity: it is one of Diodorus Siculus. By an accurate inspection of it, we should learn whether the hopes, which have been more than once entertained, of the existence of the lost books of that historian, are in this instance also to be disappointed. H. Stephanus had heard that the forty books of Diodorus were in Sicily. This report arose, probably, from Constantine Lascaris having said, in Sicily, that he had seen all these books in the Imperial Library of Constantinople. Lascaris fled from this city at the capture of it by the Turks. In the turbulence and confusion of that period, the entire copy to which he referred might have been lost. 'Deum immortalem,' says Scaliger, 'quanta jactura historiæ facta est ammissione librorum illius bibliothecæ, præsertim quinque illorum qui sequebantur post quintum."

Mr. Walpole has given a list of the books in the library of Patmos, as copied by the Marquis of Sligo.

Notwithstanding the sanguine expectations of the admirers of ancient literature, very few valuable MSS. have been discovered of late years; and it must be admitted, that even those accidentally rescued from destruction were in general of comparatively modern date, or of little consequence. Neither the inquiries which have extended to the African states, nor the researches at Herculanæum, have recovered the lost historians, or any works of importance. It was common to make written copies of the Classics after the introduction of printing, and the older editors seem to have been very unskilful judges of the antiquity of MSS.—*Memoires de l'Academie des Inscrip.*, tom. vii. *Nouveau Traité de Diplomatique par deux Benedictins.* Villoison, *Anecdota Græca*, tom. ii. Fabricius, *Bibliotheca Græca*, tom. xiv.

Many of the Romans had libraries. Lucullus instituted one, which was enlarged by Sylla from the plunder of Greece, and destined for public use by Julius Cæsar. Cicero observes, that he studied in it. Libraries were established by several of the emperors, as Augustus, Tiberius, Vespasian, Trajan, and others. Even Domitian sent to foreign countries, for the purpose of storing his library, which was consumed by lightning in the reign of Commodus, and restored at great expence by the emperor Gordian, who added to it 62,000 volumes, which had been bequeathed to him by his preceptor Quintus Serenus Samonicus. The most magnificent of all was the Ulpian library, founded for the benefit of the public by Trajan, where the books carried from the conquered cities were deposited. In the time of Constantine, there were 30 public libraries in Rome. This emperor formed a library of 120 000 volumes at Constantinople, which was greatly enlarged by his successors, but destroyed by fire; and was afterwards renewed by Leo Isaurus, who himself ordered it to be burnt. Zonaras says, that there was a manuscript of the Iliad and Odyssey here, on the skin of a dragon, 120 feet long: *Annales*, tom. ii.

Little is recorded of the libraries of the middle ages between the destruction and revival of literature in Europe. But every æra has produced learned and inquisitive men, by whom books were prized. Cassiodorus, minister of Theodore king of the Goths, retired to a monastery which he had built, and founded a library there for the use of the monks, about the year 550. Some time later, Charlemagne founded a library near Lyons, which historians affirm contained books bound in a magnificent manner. After this monasteries almost exclusively possessed libraries; and such collections, formed by the accessions of centuries, are still to be seen on the continent.

Our observations shall be confined chiefly to a few of the more celebrated modern European libraries, for a full account of them all would lead us into very copious details. Louis Jacob, a Carmelite, who wrote on this subject in the middle of the seventeenth century, enumerates above 1100 libraries, ancient and modern: *Traité des plus belles Bibliotheques.* Many of these, however, were contained in monasteries, now suppressed.

Among the libraries in Italy, a country always the seat of literature and the arts, the Vatican at Rome is predominant. Certain zealous authors have written, that St. Peter the Apostle first established a library, belonging to the Roman church, which, after augmentation by some of the Popes, was carried to Avignon, and then brought back to the Vatican, their ordinary abode. But authentic history proves, that Nicholas IV. who was elected to the papal chair in 1477, laid the foundation of this library, and supplied it with many MSS. from Greece, and that Sixtus V. spared no pains on its embellishment; nor was it neglected by any of the others down to Pope Pius VI. Some of its most valuable acquisitions came from the collection of the Elector Palatine, which was taken in 1622, by the Duke of Bavaria, who presented it to Urban VIII. Queen Christina of Sweden also had collected 1900 manuscripts, which, on her decease, descended to the chief of the Ottoboni family, afterwards Pope Alexander VIII., who deposited them in the Vatican. The exact number of books found here is not known, as there is no published catalogue of the library: but there are 10,000 volumes of manuscripts, and having consisted of manuscripts originally, the printed books are said not to be in equal proportion. Nevertheless they are very numerous; and the whole library is chiefly contained in an immense gallery, 214 feet long, and 48 broad, and in other apartments superbly decorated by the hands of eminent painters. A particular chamber is called the Papyrus room, from the quantity of writings it contains on the Papyrus of the Egyptians. Among the MSS. are preserved one of Virgil, written in capitals, on 901 folio pages of vellum, supposed to be of the seventh century: One of Terence, in 92 folio pages, also on vellum, with figures, as old as the tenth century. Both these celebrated MSS. have been published, but the reader must beware of considering the printing of the former a fac-simile, such as we are accustomed to publish in this country, though generally believed to be such, for there are only approximations to it. In the Vatican are preserved a parchment roll, 217 feet long, and 33 inches broad, containing the Pentateuch, in Hebrew, written in the ninth century; an Arabic MS. of the ninth century, of two of the evangelists, on cotton paper; a Coptic MS. on 279 folio pages of vellum, of the Pentateuch, written in the tenth century; a MS. of the laws of the Visigoths, of the eighth century; a copy of some of the works of Gregory of Tours, of the ninth; and many other MSS. of equal value and curiosity, such as Cæsar's Commentaries, of the twelfth century; the Acts of the Apostles, written in gold letters, presented by a Queen of Cyprus to Pope Alexander VI., and the like. Pope Pius VI. added a superb collection of engravings to the library, which also possesses numerous curiosities, accumulated by purchase and donation, *Massi Catalogue Indicatif.* During the progress of the late usurpations of the French, they demanded 500 valuable MSS. from the library of the Vatican, along with early printed works, and 5000 or 6000 medals, which were delivered to their commissioners, at Rome, in July 1797: *Bibliotheca Vaticana*, p. 136, 146. This library is divided into three portions; one is public, whither all may resort on two days of the week; another is of more difficult access; and the third is reserved for the reception of only very few persons. There are besides several extensive libraries in Rome, as the Barberini, containing about 50,000 printed books, and some thousands of manuscripts. The Colonna library, distinguished by about 400 volumes of books and engravings of the fifteenth century; and the library of the Roman College, wherein is contained the library and museum of the celebrated Kircher: Vasi *Itineraire*, p. 552. The remaining libraries in Italy are numerous; as at Bologna, Florence, Milan, Mantua, Pisa, Venice, and elsewhere. The Medicean library at Florence is deposited in a spacious edifice, designed by Michael Angelo. It consists of above 90,000 printed volumes, and 3000 valuable manuscripts. The latter have been described in a catalogue of eleven folio volumes, by Assemanni, Biscioni, and Bandini: and 3000 volumes, printed in the fifteenth century, are also described in two folio volumes by one of these authors: *Cambiagi Guida*, p. 47, 164. In the library of St. Mark at Venice, there is a copy of the evangelist of that name, which is affirmed to have been written by himself. Pope Julius III. is said to have ordered 12,000 Hebrew manuscripts to be destroyed at Cremona, because that language was written by a people hostile to Christianity. Gallois, *Bibliothèques de l'Europe*, p. 23.

The literature of Spain is exceedingly restricted, and the whole nation can boast of very few libraries truly valuable; for the importance and extent of a collection are to be separately appreciated. The library of the Escurial, however, contains about 130,000 volumes, of which 4300 are manuscripts, said to constitute its more interesting part. A fortress belonging to the Emperor of Morocco had been taken, wherein 4000 Arabic MSS. were found, and carried to Paris for sale, but not being prized there, they were transported to Madrid, and about 3000 selected by the command of Philip II. Most of the library was destroyed by fire in 1671, when a large proportion of the Arabic MSS. perished. In 1760 and 1770, Michael Casiri, a learned ecclesiastic, published a catalogue, in two folio volumes, of 1805 that had escaped, to which he added as many as make 1851 in the whole: *Bibliotheca Arabico-Hispano Escurialensis.* Besides those which are extremely curious, there are MSS. in various other languages: as one of the four evangelists, written in gold letters, on 160 leaves, supposed to be 700 or 800 years old—a treatise by St. Augustine, *de baptismo parvulorum*, said to be in his own hand—the original works of St. Theresa—and a parchment roll containing an original Greek MS. of St. Basil. The library of the Escurial was founded by Charles V. There are three public libraries in Madrid, besides those in Monasteries; the Royal Library, that of San Isidro, and the library of the Duke de Medina Sidonia. The first consists of about 200,000 volumes, according to the librarian, but judging by the space they occupy, this number is thought to be exaggerated. Almost the whole books published in Spain, as well as the best foreign works, are purchased for the library. A porter is stationed at the door to see that the injunctions respecting the dress of its visitors are observed: Fischer's *Travels*, p. 193. In some of the Spanish libraries the books are arranged with the front or edge presented to view, instead of the back, as with us.

Although there are many extensive and valuable libraries in France, those of Paris are the most distinguished, particularly the National Library, which is unrivalled in the world. This immense depot of literature, formerly called the King's Library, is of obscure origin. It appears that Charles V. had a library of 910 volumes, in the fourteenth century, which is said to have contained originals or translations, of the Greek and Roman Classics: but it was entirely dissipated. Another collection, founded by Louis XI. was enlarged by Francis I. who had a decided predilection for Greek literature. Not content with directing his ambassadors at the various European courts to procure Greek MSS. in the course of their respective missions, he sent three travellers to the Levant for that special purpose, who brought home 400 volumes. The celebrated Budæus was appointed librarian by that sovereign; which office he held until he died, in 1540. In 1661, the library consisted of 16,746 printed and manuscript treatises. The acquisitions of the National Library have been numerous, from the accession of other entire libraries, and of late they have been very numerous, both by purchase and plunder. It is entitled to two copies of every work published in the kingdom. In the year 1785, it contained 200,000 printed volumes, 60,000 manuscripts, 5000 volumes of prints, and 2000 engravings; since which period it has been much increased. Its contents are at present computed to be 350,000 printed books; between 70,000 and 80,000 manuscripts, and, it is computed, 50,000 portraits. There is no complete catalogue of this vast collection. A catalogue of the manuscripts in ten folio volumes, under a systematic arrangement, was published during the reign of Louis XVI. Recourse must be had to the library itself, or its catalogues, to form any correct opinion of its contents, which, in general, may be said to consist of all that is interesting, rare, and precious in literature. The MSS. embrace every different branch of learning of all ages. A written roll of papyrus, taken from the hand of a mummy in Egypt, was presented to it by Buonaparte, after he left that country in 1801. A manuscript, containing the works of Prudentius, who was born in the year 348, in rustic capitals, is supposed to be contemporary with that author. The National Library is rich in early printed works, and those on vellum; and all the arts and sciences are copiously treated of, together with history, in the modern part of the collection. By good fortune, it has constantly been committed to the charge of learned individuals; and it is now divided into two departments, each under skilful superintendence. It is conducted on the most liberal principles, open five hours daily, and so completely accessible to the public, that it is supposed about 200 persons are constantly engaged here during summer, and about 50 during winter. Not more than 10 or 12 antiquaries are usually occupied with the manuscripts. Known literary characters are allowed the use of books at their own residence, which is seldom productive of inconvenience to others, from there being frequently several copies of a work; and losses to the library are very rare: *Essai Historique sur la Bibliothèque du Roi*; Pinkerton's *Recollections*, vol. ii. Above 10 other public libraries are open in Paris; and before the Revolution there were 32 of celebrity.

The collection next in extent and value to the National Library of France, is the Imperial Library of Vienna, contained in an edifice 242 feet long, of fine architecture, and decorated with columns and pilasters. It was founded by the Emperor Maximilian, in 1480, and enriched by subsequent accessions, among which is the entire collection of Prince Eugene. The contents of the Imperial Library, above twenty years ago, were computed at 300.000 printed books, and from 12,000 to 15,000 manuscripts, all arranged according to size. Besides these there are 700 large volumes of prints, 200 of which are occupied by portraits, from every country, and of all periods. In this superb assemblage of literature, there are above 7000 volumes printed in the fifteenth century, many of them of excessive rarity, and almost unique at the present day. One of the scarcest works is the *Christianismæ Restitutio*, by Servetus, printed in 1553, in octavo, of which it is said only another copy was known to exist in the library of M. Gaignat, at Paris, where it was purchased for ₤200. The one in the Imperial Library was presented by a nobleman to Joseph II., who bestowed on him a diamond, worth 10,000 crowns, in return. Here are preserved a celebrated manuscript of Livy, conjectured to belong to the fifth century; a fragment of St. Mark and St. Luke, in gold and silver characters; and a Mexican manuscript, in coloured figures, executed on a human skin, deemed unique in its kind. An extraordinary specimen of chirography, by a Jew, is seen on a single page, eight inches long, by rather more than six broad, whereon are written, without contractions, and very legible by the naked eye, the Pentateuch and Book of Ruth in German; Ecclesiastes in Hebrew; the Canticles in Latin; Esther in Syriac; and Deuteronomy in French. The last line consists of 305 letters. This library is open daily, and is much frequented: *Voyage de deux Français*, tom. v.

The library at Dresden is kept in a handsome edifice, which forms a hollow quadrangle, almost square, with seventeen windows on two of the external sides, and fifteen on the two others; and on the internal side are eleven windows by seven. The ground floor is reserved for antiques, and the books are lodged in the first and second story. Two very spacious galleries and ten chambers occupy the first; the second consists of one gallery and nine apartments. In this library are above 150,000 printed volumes, and 5000 manuscripts. One of the latter is in Mexican characters, on the human skin, which Thevenot has explained to be a calendar, and some fragments of the history of the Incas. There are also a fine copy of the Koran, which belonged to Bajazet II. and was taken from a Turk by a Saxon officer at the last siege of Vienna; and the original MS. of the Reveries of Marshal Saxe, bearing to have been written by him in thirteen nights, and concluded in December, 1733, while labouring under a fever. Among the printed books are 600 of the Aldine editions, and many on vellum. A copious collection of antiquities is preserved in twelve apartments under the library, below which are eighteen vaulted cellars, stored with a vast quantity of valuable porcelain, of foreign, and likewise home manufacture, for which the city is so famous.

The library of the University of Gottingen is said to exceed 150,000 volumes: That of Munich amounts to 100,000, including a valuable collection of manuscripts. At Stutgard, the late King of Wirtemberg commenced the formation of a library, which, in 1791, amounted to 100,000 volumes, contained in an edifice constructed of wood. There were then 9000 Bibles, of all editions, and in all languages; and the royal owner still required 3000 copies, which, we believe, he afterwards acquired, to render his collection complete. The university of Prague has a library consisting of 130,000 printed volumes, and 8000 manuscripts, deposited in a quadrangular building, nearly 250 feet in length by 150 in width. It contains a complete collection of Polyglot Bibles; and among the manuscripts are a copy of Justin, on vellum, of the 13th century, in good preservation; one of Pliny, also on vellum, written by order of the magistrates of the city, in 1350, beautifully executed, and well preserved; and a table of logarithms, in the handwriting of Tycho Brahe.

There are few celebrated libraries in Poland, as may be expected from the political distractions of that country. What is called the King's Library, at Warsaw, does not exceed 20,000 volumes, most of which are modern. A manuscript, in three folio volumes, with 172 fine drawings, describes the antiquities dug up at Velleia, between 1760 and 1765. The university of Cracow has a library, in which are 4000 manuscripts; and among them is seen a Latin Encyclopædia, in a large folio volume, written by Paul of Prague, in 1459. A more valuable and extensive collection, called the Zaluski Library, or Library of the Republic, was formed, and devoted to the public by two brothers of that name in 1745. But no funds were appropriated, either for its enlargement or suitable preservation. Originally the Zaluski library consisted of 300,000 volumes, comprising 52,000 duplicates. By the sale of these, and from other circumstances, the collection was supposed, in 1791, not to exceed 200,000 volumes, while its value was not proportioned to its size. But it suffered many depredations, and at length was sent by General Suwarrow to St. Petersburg in 1795, where it was deposited in three elegant apartments, and opened for the use of the public in 1812. It was formerly divided into five general classes of literature; but, according to the recent work of Müller, half its contents are theology; and the portion embracing jurisprudence is distinguished according to languages. The same author observes, that this is the only public library in the capital of the Russian empire. The library of the Academy of Sciences, which some time ago exceeded 40,000 volumes, was founded with 2500 taken by Peter at the siege of Mittau. It contains numerous diplomatic papers of the reign of that prince, and the most extensive collection of Chinese works in Europe, amounting to 2800 different treatises, of which there is an exact catalogue; some Japanese manuscripts, and several of the Mongols and Thibet. The original MS. instructions, in the handwriting of the late empress, to prepare a new code of laws for her vast empire, is preserved in a fine bronze vase, which is always placed on the table during the sittings of the academy: Müller *Tableau;* Baemeister *Essai.*

Previous to the late siege of Copenhagen, the royal library exceeded 130,000 printed volumes, and 3000 manuscripts, all contained in a gallery 252 feet long, and other apartments. Among the manuscripts is an imperfect copy of Livy, ascribed to the sixth century; about 250 treatises collected by Niebuhr during his interesting travels in the East; and four large volumes of paintings of plants, on vellum, from nature, by the celebrated Madame Merian. A large portion of the duplicates of this library, particularly those relative to natural history, were purchased, some years ago, by an intelligent Scotch bookseller, and carried to Edinburgh.—Copenhagen had also to boast of one of the most extensive private libraries of modern times, in the collection of Mr. Suhm, well known by his taste in northern antiquities. It consisted of 60,000 printed volumes, besides manuscripts procured at great cost.

The king's library in Stockholm is said not to exceed 20,000 volumes and 500 manuscripts. A copy of the Evangelists, written on purple vellum, and supposed to belong to the ninth century, is commonly called the *codex aureus*, from the quantity of letters in gold.—The library of the university of Upsal, containing 50,000 volumes, is possessed of a manuscript of still greater celebrity, also a copy of the Evangelists, written in gold and silver letters, on 187 leaves of vellum, but wanting the beginning and end. The manuscript is ascribed to Ulphilas, bishop of the Goths, who flourished under the Emperor Valens, about the year 370. Junius, and also Ihre, have published dissertations regarding it.

The principal libraries in Great Britain, are the Royal Library, those of the British Museum, Oxford, Cambridge, and the Advocates' Library in Edinburgh. It is calculated that the royal library amounts to 80,000 volumes, which have been acquired chiefly by his present Majesty. The library of the British Museum, which is now considered the national deposit of literature, has been composed of various others, successively obtained, and is chiefly valuable for its numerous manuscripts. These are principally formed of the collections made by Sir Robert Cotton, who was born in the year 1570, and by the Earl of Oxford, who died in 1741. The library of the former was put under sequestration in the reign of James, owing to the appearance of a political pamphlet falsely ascribed to the owner, because a copy, under another name, was discovered among its contents. It was purchased for the use of the public in 1701, and annexed by statute to the British Museum in 1753. This library originally consisted of 958 volumes of manuscripts, which were reduced to 861 by fire in 1731. A complete catalogue, lately published by order of government, in one volume folio, embraces 26,000 articles, which, in general, relate to British history. The Harleian MSS. amounted to nearly 8000 volumes at the death of their noble owner. Now they exceed 10,000 volumes, besides above 40,000 original rolls, letters patent, signs manual, &c. for the most part relating to great Britain and Ireland. It is difficult to form a correct idea of this copious collection without actual examination. There are numerous ancient MSS. of the classical authors: such as a fragment of the Æneid, and a copy of Quintilian, of the ninth century; two copies of Terence, and one of Homer and Ovid, of the tenth; and a copy of Sallust, of the eleventh. Here are about 300 manuscript Bibles and biblical books, in Hebrew, Chaldee, Greek, Arabic, and Latin, nearly 200 volumes of writings of fathers of the church; numerous missals, breviaries, and liturgies; an extensive collection relative to the topography and antiquities of Great Britain; many volumes of original letters from celebrated natives of the island and foreigners; works on the arts and sciences—among which is a tract on the steam engine, with plans, diagrams, and calculations, by Sir Samuel Morland, who styles himself master in mechanics to Charles II. A catalogue of the Harleian MSS. has been recently published by order of government, in four volumes folio; one in an abbreviated form, of the printed books in the British Museum, is just about being concluded, in several octavo volumes. These libraries are open daily, and, on a suitable recommendation, any person is introduced to study in the reading room; but no manuscript may be copied without special permission. There are several other libraries in London belonging to public bodies: That of Sion College, an institution for education of the clergy, is entitled to a copy of every book published in the kingdom.

The different colleges of the universities of Oxford and Cambridge have libraries of various extent, of which the Bodleian collection is said to be the most ample in Britain. This was instituted towards the close of the reign of Queen Elizabeth, by Sir Thomas Bodley, who collected 1294 rare manuscripts, which were afterwards increased to 6818, independent of 1898 in the Ashmolean museum. A catalogue of part of those relating to oriental history was executed by J. Uri, a Hungarian, and published in a folio volume in 1787. The printed works are numerous and valuable.

The library of Trinity College, Cambridge, is extensive, and contained in a large apartment, floored with black and white marble. Here, among other literary curiosities, are some of Milton's poems, in his own writing. A valuable collection of manuscripts, by Parker, Archbishop of Canterbury, is deposited in the library of Corpus Christi college, several of which are ascribed to the eighth, ninth, and tenth centuries.

Two private collections in England demand notice; the one from use, the other from curiosity. The first is the library of Sir Joseph Banks, comprehending every department of natural history, together with a copious collection of the transactions of learned societies; and its value is enhanced by an excellent catalogue, according to the most scientific and systematic arrangement, in five octavo volumes. The second is the library of the Earl of Spencer, amounting to 45,000 volumes, and which is understood to be the most extensive belonging to any individual in the united kingdom. It was founded chiefly on that of Count Revicsky, a foreign nobleman, who addicted himself to the collection of works of a very peculiar description, and contains an unexampled assemblage of those illustrating the origin and progress of typography. Here are several books consisting of impressions from wood on blocks, previous to the invention of metallic types; thus exhibiting the earliest specimens of stereotype, so lately revived. In some, engraved figures constitute the principal part, to which is annexed a small proportion of text, and only one side of the leaf is employed. Such is the *Ars memorandi notabilis per figuras*, supposed to have been thrown off previous to the year 1430, which consists of a number of rude cuts of the principal events recorded in the Gospels, with text on the opposite page; *Ars moriendi*, of which the subject is a sick man in bed, surrounded by grotesque and hideous figures of devils and angels. Something monstrous or absurd was the fashion of the time, as we see in sulptures of various kinds; and, in the former work, St. Luke is represented by a bull standing on his hind legs, while St. Mark is introduced as a rampant lion; *Historia Veteris et Novi Testamenti, seu Biblia pauperum*, is previous to the year 1450, but which some have considered the earliest specimen of block printing. Besides these and others denoting the infancy of the art, the Spencerian library contains a fine collection of early printed and scarce Bibles; as the Mazarine Bible, ranked between 1450 and 1455; one, supposed the work of Albert Pfister, anterior to 1460; Fust and Schœffer's Bible, 1462; that by Sweyheym and Pannartz, 1471; a Dutch Bible, 1477; Prince Radzivil's Bible in Polish, and those in the different European languages. Here are seen the Latin Psalter of Fust and Schœffer of 1457, being the first printed book to which a date is affixed; and another of nearly equal rarity, of 1459. Many of the earliest editions of the classics, beautiful copies on vellum, and the works of all the celebrated printers of the 15th century, add to the value of the collection. An accurate opinion of the nature, value, and importance of these, to persons who consider science as secondary to the medium of imparting it, may be formed from the laborious catalogue of Mr. Dibdin, in four royal octavo volumes, which at once carries the reader back to the earliest ages of the typographic art in every variety.

The library of the university of Edinburgh consists of about 50,000 printed volumes, and a few manuscripts. An abbreviated catalogue of the medical books, including some on natural history, together forming the most complete part of the collection, is published in an octavo volume. The library is under good management, and the respective demands of the numerous readers are expeditiously supplied. The advocate's library in Edinburgh was founded in 1680, by the exertions of Sir George Mackenzie, and now consists of about 80,000 printed works, and 1000 volumes in manuscript. Its most copious subjects are the national history, Greek and Roman antiquities, and jurisprudence in general. Among the manuscripts, there is a fine copy of Martial's Epigrams, in perfect preservation, which has been ascribed to the ninth century; the most ancient, in so far as we are aware, that is known to exist. This work is written in double columns, on 108 leaves of a peculiar kind of vellum, such as is not in use at present, in the small Roman character, with the titles of the epigrams in rustic capitals. Instead of the uniform division of syllables, the words frequently run into, and are united with each other, as in the most ancient manuscripts, or being irregularly divided, the first syllable is annexed to the word preceding, while the last is prefixed to that which is subsequent. The ancient mode of punctuation is particularly exhibited among the capitals. Here are, besides, a fine copy of Valerius Maximus on vellum, dated 1398, which merits collation; and fragments of several other classics, as Juvenal, Persius, and Ovid, of considerable antiquity. In the advocates' library are preserved thirteen of the chartularies, or volumes of records of the different religious houses of Scotland, which escaped the general destruction in which the edifices themselves were involved, in promoting the reformation of religion; a folio volume of music for the service of the cathedral of Scone, written in the sixteenth century; several papal bulls and original charters. The records of the religious houses are particularly valuable, from ascertaining the ancient owners of property, which is often important in legal proceedings, illustrating the antiquities of the country, and from presenting a greater number of writings of the twelfth and thirteenth century, than are elsewhere collected together. Law, and subjects of national history, occupy the great bulk of the manuscripts, which are of very unequal value. There are a few works of old English history, numerous letters of distinguished individuals, including one in the handwriting of Queen Mary, and several of foreigners. The printed books in the advocates' library embrace every department of science and literature, except theology and medicine, of which there are only some leading treatises. It contains several first and early editions, and many scarce and curious works; as the Mazarine Bible, as entire as when it came from the press; a Breviary of 1478, in folio, printed on fine vellum; three volumes of Rudbeck's Atlantica, &c. A catalogue, in three folio volumes, enumerates the contents of the library down to 1807. The funds for its support are ample, and its annual acquisitions are considerable. It is conducted on liberal principles, and access to it has proved beneficial to the authors of various literary works, published both in England and Scotland. This library is at present kept in eight apartments, some of which are absolutely subterraneous. Part of it, however, is about to be removed to a spacious gallery, wherein the most essential requisites for convenience and accommodation are overlooked; the consequence of inconsiderately substituting a picture, from some imaginary point of view, for a simple and unostentatious plan, suitable to the purpose for which it was intended. The attornies or writers to the signet of Edinburgh have a library, computed at about 15,000 or 20,000 volumes; of which there is a systematic catalogue in a quarto volume.

The library of the university of St. Andrew's contains about 36,000 volumes; that of Glasgow is smaller; and about 14,000 are in the library of King's college Aberdeen. Among the manuscripts belonging to the last are, a splendid copy of the Koran, said to be the identical manuscript used by the late Tippoo Saib; a work on Hindoo theology, written on fine vellum, and rolled on a piece of ivory, after the fashion of the volumina of the ancients; and a copy of the Shaster, in Sanscrit, on the leaves of trees.

The library of Trinity College, Dublin, consists of above 40,000 printed volumes, and 1100 manuscripts, in different languages, all contained in a fine gallery, 210 feet long, 41 broad, and 40 high. Among the manuscripts there is preserved the Gospel of St. Matthew, along with other fragments of Scripture, written in Greek capitals, ascribed by Mr. Barret to the sixth century. The subjects of the remaining manuscripts are much diversified. Many relate to Irish history, particularly the troubles of 1641, concerning which there are numerous original papers. Some are written in the Latin language, which Irish characters are employed to express.

According to a subsisting law, which is about to undergo some modification, eleven libraries are entitled to a copy of every publication in the united kingdom. These are, the royal library, British museum, Sion college, the universities of Oxford and Cambridge, Edinburgh, St Andrew's, Glasgow, Aberdeen; the advocates' library in Edinburgh, and that of Trinity college, Dublin.

In respect to eastern libraries, we shall briefly remark, that they are, for the most part, very limited. There are 13 public libraries in Constantinople, none, except perhaps the Turkish emperor's, exceeding 2000 volumes, of which a catalogue was obtained, with great difficulty, by the Abbe Toderini. Inspection of it, as printed by that author, will demonstrate of what Turkish literature consists. The libraries have several attendants with fixed salaries; and in some of them are seen translations of British and continental publications into the Turkish language. Until its publication, with which we are not aware that Mr. Walpole is acquainted, several of the lost classics were supposed to be deposited here. Toderini *Letteratura Turchescha*, tom. ii. p. 53. At Seringapatam, the library of Tippoo was taken, consisting nearly of 2000 volumes, many of which are highly decorated. Stewart's *Catalogue.* There are considerable libraries in China and Japan, and also in the capital of the kingdom of Ava.

The Emperor Leopold and the Elector of Bavaria commenced a library of music in the seventeenth century, which Dr. Burney suggests should be done on a regular plan; and gives a sketch of the arrangement to be preserved. But the reader will find a more comprehensive and useful system in a German work, published last year, 1817, at Leipsic, entitled *Musical Literature*, which is divided into 88 different branches, containing a complete catalogue of all music, the number and species of instruments for which it is composed, the price, and place of publication. In 1794, a musical library was instituted at Paris, but principally with a view to instruction in the art.

It is not enough that a vast assemblage of books shall be collected together, they must be deposited in suitable receptacles, and rendered useful and accessible, from a proper arrangement of their names in a catalogue. Some libraries are contained in one large apartment; others as extensive in several of smaller size, which seems preferable. As books consist of perishable materials, air and heat are essential to their preservation. Where a library is already completed, its contents may be deposited in different compartments according to their subjects; but this does not appear a convenient distribution for one in a state of progressive enlargement. There it will be more beneficially effected merely according to size, while the contents are explained in catalogues, framed under a systematic form. But although the utility of such catalogues be indispensable, as without them it is impossible to repress exuberances in certain branches, or to supply deficiencies in others, the learned are not agreed on the best and most comprehensive system; whence the catalogues of the greater number of libraries are prepared simply according to the names of the authors of the various works. The great difficulty seems to consist in fixing on leading heads. Some of these are obvious, but some frequently adopted are obscure: however, it is evident, that any division separating printed treatises from those in manuscript, or classifying books according to language, must be defective. Bacon, Diderot, and other learned men have maintained, that all human knowledge rests on three fundamental principles, memory, reason, and imagination, by which latter we presume invention is also to be understood; that memory is the source of history, reason of philosophy, and imagination of poetry. It has been proposed to classify the catalogue of a library according to these and their subordinate branches. By some authors, they have been farther interpreted thus: 1. Memory, or history; 2. Reason, philosophy or science; 3. Imagination, poetry, liberal arts, mechanical arts. It has been also proposed, to arrange a catalogue under the five branches, theology, jurisprudence, history, philosophy, and belles lettres, and such was the plan principally followed of late in the national library at Paris. But in Britain, the word philosophy is now of very doubtful interpretation; and belles lettres is so exceedingly vague and indefinite, that miscellanies perhaps would be equally explicit. A system less defective, though also in five parts, is proposed by Debure, in theology, jurisprudence, sciences and arts, belles lettres, history. This removes the great difficulty of the plan of Bacon and Diderot, which places works on sculpture and architecture along with those of fable and romance; an arrangement quite repulsive to modern ideas of the dignity of science, and the importance of the arts. Debure classified several useful catalogues accordingly, by which *theology* is subdivided into, 1. Bibles, interpreters, critics, commentators; 2. Councils, liturgies, fathers; 3. Theologians. *Jurisprudence* into, 1. Canon law; 2. Civil law. *Sciences and arts* into, 1. Philosophy; 2. Physics; 3. Natural history; 4. Medicine; 5. Mathematics; 6. Arts. *Belles lettres* into, 1. Grammar; 2. Rhetoric; 3. Poetry; 4. Philology; 5. Polygraphy. *History* into, 1. Historical prolegomena; 2. Geography; 3. Chronology; 4. Ecclesiastical history; 5. Profane history of ancient monarchies; 6. Modern European and foreign history; 7. Historical paralipomena; 8. Antiquities; 9. Literary, academic, and bibliographical history; 10. Biography; 11. Historical extracts. This system is founded almost exclusively on that of Gabriel Martin, who divides literature into the five primitive classes adopted by Debure, and who, by the arrangement of no less than 148 catalogues, had an opportunity of reducing his theory to practice. These systems have been followed, in many instances, with very little alteration, though probably from being more generally known. Denis, the imperial librarian at Vienna, proposes an arrangement under seven different heads, which probably could be adopted with considerable convenience; theology, jurisprudence, philosophy, medicine, mathematics, history, philology. He considers that theology is connected with jurisprudence by the ecclesiastical councils; jurisprudence with philosophy by the law of nature; philosophy with medicine by natural history; medicine with mathematics by anatomy; mathematics with history by chronology; history with philology by heroic fables; and that philology is connected with theology by mythology. Another system, rather more explicit, was offered at Jena, which divides literary works into sixteen different classes: 1. The knowledge of books; 2. Philology; 3. Theology; 4 Jurisprudence; 5. Medicine; 6. Philosophy; 7. Pedagogy; 8. Science of the statesman; 9. Science of the soldier; 10. Knowledge of nature; 11. Knowledge of arts and trades; 12. Mathematics; 13. Geography and history; 14. Fine arts; 15. Literary history; 16. Miscellanies. We shall say nothing of the system proposed by M. Thiebault; for it does not seem applicable to practice. A system in very copious detail is suggested by M. Peignot, the author of several works on what is now called bibliography, a subject which as yet has not been reduced to any fixed principles. This is chiefly founded on the three great sources of knowledge, according to the philosophers before named, memory, reason, and imagination, preceded by the article bibliography. M. Peignot enumerates about 250 different heads, under which the books may be arranged; but we cannot see on what sound principle *natural history* is ranked under HISTORY; and the *science of nature*, comprehending some of its most essential parts, under PHILOSOPHY. Neither can we reconcile the position of the *military art*, which stands between engraving and music, with the principles of analogy. What is now said, sufficiently evinces the difficulty of classifying the catalogue of a great library according to any unobjectionable system; yet it is not absolutely essential that such arrangement should proceed on the most refined principles; for a few general heads, each branched into details, will prove exceedingly convenient, though they are not intimately connected together. If all the works on the military art, all those on engraving, and all on music, are entered respectively under three different branches, the welfare of the library to which they belong, is in no respect dependent on their being ascribed to either *science* or *the arts*, their proper places, or to the fruit of *imagination*. M. Peignot's work may be very profitably consulted for details: See *Dictionaire Bibliographique*, tom. ii. p. 271. The principal object is to associate works on analogous subjects, for it is from this juxtaposition that utility is derived. The most convenient arrangement of a catalogue, therefore, seems to be according to matter, along with an *index auctorum*. In one department, *natural history*, the catalogue of Sir Joseph Banks forms an excellent model, specifying the subject of every treatise, its extent, and the number of plates; besides which, there is, in many instances, an obituary of the authors. Another catalogue, not of a library indeed, but of all works connected with mathematics and physics, was lately published by *F. G. A. Murhard*, in five octavo volumes, which proves exceedingly useful to those pursuing such studies, and is also a satisfactory guide to the classification of a literary collection.

Rules for the formation of a library, must be dependent on the taste of the age, and the purpose for which it is designed, whether private or public. Hence few of those laid down by Gabriel Naudé, in his *Avis pour dresser une Bibliothèque*, are now applicable with respect to the selection of works. Nevertheless there are authors, historians, moralists, and explorers of natural phenomena, who will be always prized, because their writings are founded on immutable truth. Some collectors have addicted themselves to the early editions, to certain sciences, to arts and trades, to works whose chief embellishment is engravings, or to those merely printed on a large size of paper. It is by the union of all these peculiarities that a great public library is formed. But its basis ought to rest on original works of truth, for they alone are the source of knowledge: commentators and critics hold a secondary place; and works of fiction may be introduced for amusement. The extent of a library is indefinite. One of the ancients, celebrated for his learning, is said to have possessed only four volumes. Leibnitz declares, that his library had no more than the works of Plato, Aristotle, Archimedes, Euclid, Plutarch, Sextus Empiricus, Pliny, Cicero, and Seneca. Lenglét du Fresnoy makes a calculation, whereby it appears that no one can read above 900 folio volumes in his life; from all which is deduced the inutility of extensive libraries. These remarks will not apply to those collections destined for public use; but the words of Seneca never should be forgot, *non refert quam multos libros, sed quam bonos habeas*, inferring, that the quality of books, not their number, is the primary consideration. (*c*)

LIBRATION. See ASTRONOMY.

LICHANOS-HYPATON, in the music of the Greeks, implied the D, next below the bass cliff of our modern scale.

LICHANOS-MESON, in the music of the Greeks, implied the G, next above the bass cliff of our modern scale.

LICHEN.

LICHEN is the name for an extensive natural order of plants, in the lower scale of the vegetable creation. They appear generally in the form of crusts, covering rocks and the bark of trees. In English, they are known under the comprehensive denominations of *rock-moss* and *tree moss*; but few of the species are distinguished by particular names. The dye-stuffs called *orchal*, and *cudbear*, are kinds of lichen; and so are the *oak-lungs*, and *ground-liverwort*, which at different times have been in estimation as medicines, the former in pulmonary complaints, and the latter for the bite of a mad dog.

By the older botanical writers, the lichens were classed along with the frondose musci. Our countryman, Morison of Aberdeen, Professor of botany at Oxford, towards the end of the 17th century, was the first who separated them. He formed them into a genus, under the title of *Musco-fungus*, their leathery substance leading him to consider them as allied to the fungi. Tournefort, in the *Institutiones Rei Herbariæ*, 1700, first applied to them the general term Lichen; but he made a separate genus of those having a coralline shape, describing them along with certain fungous plants, such as clavariæ, under the title of Coralloides. Micheli laboured indefatigably in illustrating the lichens. In his *Nova Plantarum Genera*, 1729, they are divided into no fewer than 38 sections, and nearly 300 species are described, and not a few of them delineated. Dillenius, in his *Historia Muscorum*, 1741, arranged them under the names of Usnea, Coralloides, and Lichenoides, leaving the simple word *lichen* to signify the officinal liverwort. The filamentous species were associated with the confervæ, under the first-mentioned title of Usnea; the former being Usneæ arboreæ, and the latter Usneæ aquaticæ.

The justly celebrated Linnæus employed himself chiefly in investigating phænogamous plants, by means of which he was best able to establish his sexual system. In the algæ, he did little more than arrange and adapt to his own views the plants described by Micheli, Dillenius, and others. He greatly reduced the number of species of lichens, on account, it is presumed, of the vagueness of the descriptions given by preceding writers, which did not enable him to construct regularly the compendious, but luminous specific characters in which he delighted. He comprehended the whole under one great and heterogeneous genus, Lichen; but he divided it into eight sections, distinguished by the general habit and appearance of the plants: 1. Crustaceous, with tubercles; 2. crustaceous, with shields; 3. tiled; 4. foliaceous; 5. leathery; 6. bearing cups; 7. shrub-like; and 8. filamentous.

Since the time of Linnæus, great progress has been made in the investigation of the lichens. The distinguished Hedwig, and the still more accurate Gaertner, examined with care the mode of propagation of this tribe of plants, a subject which had hitherto been little attended to. But the author who principally extended our botanical knowledge of the lichens, was Dr. Hoffman of Göttingen. Between 1784 and 1792, this laborious author published descriptions and figures of all the known species, under the title of *Enumeratio Lichenum.* He, at the same time, attempted their division into natural genera, founded, like the sections of Linnæus, on the general habit of the plants. He was succeeded in this department of botany by Dr. Erich Acharius, whose works, it is remarked by Sir James Edward Smith, "form a new era in cryptogamic botany, and will most likely prove the foundation of all that can in future be done on the subject." If, therefore, the illustrious Linnæus was deficient in his acquaintance with the algæ, it was reserved for another eminent Swede to elucidate this difficult branch of the science.

After some account of the structure of lichens, and of the mode of fructification, or of propagation, in this obscure tribe of plants, the reader shall be presented with a detailed view of the Acharian system. Several new terms must unavoidably be used; but they shall be as sparingly employed as possible, and their meaning carefully explained. A short account of the uses of the lichens, in domestic or rural economy, in medicine, and in the arts, will be subjoined.

Lichens are produced on the hardest and most barren rocks, and at great elevations; on old walls; on the trunks and branches of trees, whether the bark be smooth or rugged; and on the surface of the earth, particularly in moorish soils. They are found in all climates, and at all times of the year, being naturally fitted to resist, not only heat and cold, but dryness and wetness. They suffer more, however, from drought than from humidity; and in this country, like the musci, they appear to greatest advantage at the moist seasons of the year.—A few notices regarding their *habitats*, will be more intelligible after the Acharian arrangement has been explained.

Structure of Lichens.

These plants have no distinct and regular *roots.* Some species, such as the common ground-liverwort, have small fibres issuing from the edge and under surface of the frond: others are immediately attached to their place of growth, for example, to stones, as if by a sort of cement. They are equally destitute of *stems*, and also of *leaves*, properly so called. The part most analagous to a leaf, and which constitutes the principal body of the plant, is frequently termed the *frond:* by Acharius, it is denominated the *thallus.* This thallus is often merely a thin flat crustaceous expansion; sometimes, however, it is foliaceous and lobed; again, it is branched, and like a shrub in miniature; in some cases it seems to be only a pulpy or gelatinous mass; and in others, little else than a sort of powdery matter.

In the leaf-like, and in the branched lichens, the thallus is distinctly composed of two parts. (1.) The exterior is commonly hard, cartilaginous, or crustaceous, homogeneous, with scarcely any signs of organization in its texture, but abounding every where with very minute granular bodies, the nature of which will be afterwards explained. This is called the *cortical* substance. It forms both the upper and under stratum of the thallus, in most of the foliaceous lichens, being wanting below however in some of these, and also in the uniform crustaceous species; in those which are shrub-like, it surrounds the branches and ramuli. In the humid state, the parenchyma of this cortical substance is somewhat gelatinous; and in many species it consists, to the extent of half its weight, of mucilage and gelatine. (2.) The other constituent part of the thallus, inclosed by the cortical, is called the *medullary* substance. It is generally soft, cottony, or fibrous, and apparently vascular.

No spiral vessels are observable, nor have any particular kind of circulating vessels been traced in lichens. Seldom, indeed, can the structure be shown to be either distinctly vascular or cellular.

Lichens, so simple in general structure, possess in a strong degree that quality of the living principle, which tends to the formation of new parts, or to the supply of such as may have been injured. If a part of the cuticle of a coriaceous lichen be destroyed, so as to expose the internal white substance, this white part soon acquires a greenish colour, which Ramond traced to the extravasation of a peculiar juice. The different parts of lichens often grow together, or become conjoined, and the plants thus assume very various forms. Indeed, the more simple the organization, the greater seems the tendency to irregular sprouting; and the greater, of course, the dissimilarity between individuals of the same species.

Lichens are not only perennial plants, but they possess the curious faculty of continuing for years, without undergoing any perceptible change. Dr. Withering mentions one case, in which the parts of fructification of an individual lichen remained, without visible alteration, for the long period of ten years! In such kind of fructification we may confidently expect something very different, in nature and properties, from the flowers and seeds of phænogamous plants; and it will soon appear that we do meet with something very different.

Fructification of Lichens.

The fructification of lichens, or the mode in which they are propagated, has long been a botanical problem, which has exercised the talents and divided the opinions of the most acute cryptogamists. Before stating the doctrine of Acharius, therefore, it may be proper to advert to what was taught by Hedwig, and by Gaertner, as the two most distinguished writers on the subject.

Hedwig, it is well known, bestowed much pains in examining the fructification, not only of the frondose mosses, but of lichens; and, till of late, his authority was pretty generally assented to by botanists. On the fronds of many lichens, numerous small mealy tubercles, or wart-like excrescences appear, commonly of the same colour and texture as the frond. On dividing, by a vertical section, some of these tubercles in an early stage of their growth, Hedwig found them to consist of a congeries of cells, each of them containing a granulous mass. The granules he regarded as particles of pollen. When the tubercle acquires a deep brown colour, it is at maturity; the pollen then escapes, and the tubercle becomes black. Here, therefore, we have someting like a male flower, especially in the eyes of one bent on extending the sexual hypothesis to plants of every tribe. On a different part of the same plant, or on a different plant of the same species, appear a number of cup-shaped or target-shaped bodies, either sessile, or supported on short pedicles, commonly of a greenish colour, but gradually becoming dark as they ripen. When the ripe cups and shields are divided by a vertical section, they are found to contain, immediately under the dark crust at the top, a number of small egg-shaped bodies, arranged in perpendicular layers. These Hedwig considered to be the *sporæ*, or seeds; and the cups or shields were of course the female flowers.

The diligent and sagacious Gaertner took a different view. His observations led him to conclude, that the powdery matter, and minute oblong bodies contained within the tubercles, shields, or saucers, consist not of pollen or of seeds, but of a peculiar sort of gems or buds. This kind of bud he denominates the *propago*, and describes as being a simple gem, without leaves or regular shape, in some cases naked, and in others covered with an envelope. When at maturity, these gems separate from the parent plant; they are dispersed in the same way as seeds, and a new progeny springs up. They are so far analagous to seeds; but, considered physiologically, they are more strictly allied to buds.

It may here be remarked, that several of the more perfect plants are bulbiferous; as may be seen in the true Lilium bulbiferum of Linnæus, and the tiger-spotted lily of China, L. tigrinum; and in not a few of the alliaceous tribe, such as Allium carinatum, and arenarium, which are both natives of Britain: viviparous grasses are common on our upland pastures, as Aira cæspitosa vivipara, Festuca vivipara, and Poa flexuosa and alpina: and many plants can be propagated by tubers, as the common potatoe, and the Jerusalem artichoke. All such plants, it will be observed, might, in favourable situations, produce seeds; and if it be true, that nature has provided these resources, in order that the species might with more certainty be continued in inclement regions, or on sterile soils, we might naturally expect, that lichens would, in that respect, be adapted to the contingencies to which they are exposed, of being successively scorched, drenched, and frozen on the same barren rocks. It may be added, that the very simple organization of the lichens might lead us *a priori* to expect, that they would be increased by means less complicated than are observed in phænogamous plants. It is justly remarked by Sprengel, that the propagation by gems, in the less perfect plants, prevails more and more as the oganization is lower. It begins to occur in the ferns, is more general in the mosses, still more so in the hepaticæ, and most prevalent of all in the lichens and confervæ.

The opinion of Gaertner has been established by the labours of Acharius; and lichens (and probably also Fuci, or sea-weeds) are henceforth to be considered as gemmiparous plants, propagated only by bud-knots, or gongyli.

It is remarked by Acharius, that the frond, which constitutes the body of the lichen, performs the functions of a *universal receptacle*, and may be regarded in that light. The numerous processes already alluded to as generally observable on the surface of the thallus, and which, according to their shape and appearance, have been called saucers, shields, and targets, are considered as *partial receptacles*, and are by him denominated *Apothecia*. They are either *regular* or *accessory*. When they occur of similar structure in various species of lichens, and constitute a *generic* character, they are said to be regular or true; when they are variable or irregular, and afford only *specific* distinctions, they are said to be accessory. From the thallus, in many species, rises a kind of little stalk, called *podetia*, supporting the apothecium. When the stalk is very small and short, it is styled *podicella*. The propriety of employing such new terms is obvious; a *peduncle*, for example, (the parallel term employed in speaking of phænogamous plants,) sustains the flower and fruit, and springs from the stem; while the apothecia of lichens present neither flowers nor fruit, and the stalks upon which these apothecia are elevated arise from a common receptacle.

In order distinctly to see the structure of an apothecium, and the parts of which it is composed, it is necessary to make a perpendicular section; and, for this purpose it is right to prepare the specimen by moistening it gradually for some hours. The employment of a pocket lens, or small microscope, is likewise indispensable.

The apothecia of some lichens are observed at first to be covered with an extremely fine membrane, somewhat analogous, it has been thought, to the involucrum or volva of the agarici. But this membrane is not very generally found; and Acharius considers it as not otherwise useful than in protecting the apothecium when tender. The apothecia, or partial receptacles, therefore, may be regarded merely as modifications of the thallus itself, and as composed externally of the same substance, though frequently of a different colour. Upon making the section, certain vessels, disposed in vertical rows, are diplayed. These constitute the *lamina proligera*, or *gemmiparous plate*, (the *seminal layer* of Sprengel.) They are compact, firm, smooth and pellucid. Within these, numerous small bodies are observed, which are the *gongyli* or *bud-knots* already alluded to, and which are minute opaque bodies. The gelatinous substance of the gemmiparous plate being brought into a state of solution by continued moisture during autumn and winter, the gongyli probably then escape and germinate. In some lichens, the gongyli are not produced in gemmiparous plates, but in gemmiparous *nuclei*; and each neucleus is invested with a membrane called *perithecium*, which is horny when dry, and pellucid and gelatinous when wet. Both the plates and the nuclei are divided into *cells*, and often also into *vesicles*. Cells (the *thecæ* of Hedwig,) are mere oblong vessels or cavities. If these only occur, the parenchyma of the apothecium is said to be of *simple texture* (*similare*). The cells, however, are frequently compound, or contain within themselves smaller cells: these smaller cells were erroneously considered as the naked seeds by Hedwig; but they have been ascertained to contain gongyli like the simple cells; and are by Acharius distinguished by the name of *vesicles*. The cells of both kinds are often found quite empty, though outwardly perfect; yet gongyli abound in other parts of the substance of the same apothecium. Gongyli are universally to be found in lichens; cells and vesicles, however, are frequently wanting. These vessels are apt to disappear through age. They dry up, too, like other parts of the lichen, during hot weather; and on the return of the moist and cool season of the year, they again expand;—characters, it may be noticed in passing, which are quite inapplicable to seeds.

If the apothecia were to be considered as the fruit of lichens, then one and the same species of plant must be held as presenting often two, or even three different kinds of fructification; for some lichens, besides regular apothecia, contain tubercles, warts, or pores, all of which furnish the supposed seeds. These, indeed, are the parts which Hedwig regarded as the male organs, affording pollen; they do not, however, fade and disappear, after a short time, like the antheræ and stamina of flowers, but endure as long as the true apothecia. They are termed *cephalodia* by Acharius; and he mentions, that from the powder taken from some of them, the lichen has been observed to be propagated. In one great division of lichens, the apothecia may be said to be fruit shaped, and this might appear to strengthen somewhat the argument drawn from analogy; but in two other great divisions, these organs are nowise fruit-shaped, but are of the nature and habit of the thallus itself. Even where no regular apothecia, or even no powdery excrescences are to be seen, the gongyli or bud-knots are not wanting; for these are also distributed through the frond or general substance of the lichen. Some species of lichen, it is well known, very rarely produce their shields or apothecia; insomuch that a specimen containing them is prized by botanists as an invaluable treasure. This is the case, for example, with Lichen nivalis and L. glaucus, (Cetrariæ); L. pustulatus, (Gyrophora); L. jubatus, (Alectoria); L. pubescens, (Cornicularia); L. perlatus and L. physodes, (Parmeliæ); and with L. palmatus, (Collema); perfect specimens of which form what Acharius would call the "*gazæ* of a lichenologist." It has often excited surprise, that plants which so seldom presented their parts of fructification, should yet be abundantly spread over our rocks and trees. This difficulty, however, is not satisfactorily explained. These lichens, although incomplete in the eyes of the botanical collector, are, in reality, perfect plants of their kind, being enabled to reproduce the species by means of the gems dispersed in the substance of their fronds.

It may here deserve notice, that, in this tribe of plants, the reproduction by gems must be held as being as complete and permanent as that by means of seeds. It follows, that Mr. Knight's doctrine, "That the only genuine reproduction in vegetable nature must be effected by seeds," cannot be considered as of universal application, but will fall to be limited, at all events, to phænogamous plants. Perhaps it may be found to be more particularly adapted to the arboreous plants with which this ingenious writer is most conversant, and to which it seems in every respect applicable.

Lichens, therefore, according to the views of Acharius, may be described as forming a new peculiar Natural Order, distinct from the other cryptogamia; and as consisting of plants—in which the whole body, whether frond or crust, performs the functions of a universal receptacle, or *thallus*; —of various shapes;—without a distinct root or stem;—perennial;—furnished with vegetative corpuscles or *gongyli*, (analogous to, but something intermediate between seeds and buds, though most nearly allied to the latter,) by which the species is continued;—these gongyli abounding in every part of the substance of the thallus, both externally and internally, either scattered, or collected in small nests,—and at the same time existing, inclosed in separate or proper organs, which are sometimes fruit-shaped, and generally coloured, called *apothecia*, or partial receptacles.

No account, it is believed, of the Acharian genera has hitherto appeared in any English publication. It seems proper, therefore, not only to enumerate the generic names, but to detail the *essential characters*; and the subject may probably be somewhat facilitated and relieved, by mentioning a few of the more remarkble British lichens, as illustrative of the respective genera of Acharius, under which they now fall to be arranged. It may be noticed, that some years after the publication of his *Prodromus Lichenographiæ Suecicæ*, and of his *Methodus Lichenum*, Acharius gave to the world, in 1810, an enlarged and improved work, entitled *Lichenographia Universalis*, to the arrangement and nomenclature of which we shall adhere. It might perhaps be possible to dispense altogether with the terms *thallus* and *apothecium*, and merely to denominate the former *universal*, and the latter *partial receptacle*; unless the occurrence of intermediate verrucous receptacles, in some genera, should seem to present an obstacle. In the mean time we shall adopt the language, and plan of description, of the work last mentioned; not convinced, however, that it would not be better, in laying down the generic characters, to notice in the first place the Thallus, which forms the bulk of the lichen, and then the Apothecia, which are small and subordinate parts, although they afford convenient distinctive characters.

Acharius divides lichens into three great classes. 1. *Idiothalami*, in which the apothecia are different in substance and colour from the thallus; 2. *Cœnothalami*, in which they are partly formed of the thallus; and 3. *Homothalami*, in which they seem to consist wholly of a production of the cortical and medullary substance of the thallus. These three classes embrace forty-two genera, the author having considerably increased the number subsequently to the publication of his *Methodus Lichenum*. By way of appendix, a class of *Athalami* is added, in which no apothecia appear, or have hitherto been detected: This includes only one genus.

System of Acharius.

CLASS I. IDIOTHALAMI.

A. HOMOGENEI.

Genus 1. **SPILOMA.** *Apothecia* varying in shape, and coloured; swollen or tumid, without a membranaceous border, being composed of naked gongyli heaped together. *Thallus* crustaceous, uniform or of one shape, somewhat membranaceous, and scaly or powdery.

This and the next genus are not so distinctly marked as most of the others. The species of Spiloma are found on the bark of trees, or on decayed wood, having usually the appearance of a scattered dark-coloured powder.

2. **ARTHONIA.** *Apothecia* generally inclining to round-shaped; flattish, without a membranaceous margin; covered with a thin black membrane; internally, somewhat gelatinous, and of simple texture. *Thallus* crustaceous, uniform, or membranaceous, and sometimes approaching to cartilaginous.

Lychen lynceus, described and figured in Sowerby's *English Botany*, t. 809, affords an example of this genus.

3. **SOLORINA.** *Apothecia* roundish, sessile, without a border; covered with a coloured membrane; within,

subgelatinous, and containing vesicles. *Thallus* leathery, leaf-like; beneath, veined, or marked with fibrils.

This genus includes merely two species, the Lichen croceus and saccatus of Linnæus, and of *English Botany*, which were formerly ranked under Peltidea by Acharius in his *Methodus*. Solorina crocea occurs on some of the Scottish mountains, where it was first observed by Dr. Stuart of Luss; it is at once distinguished by the fine saffron colour of the under side of the frond. In S. sacata, the apothecia or shields frequently appear sunk in sockets; but this is only when the plant is past its prime.

4. **Gyalecta.** *Apothecia* circular; concave, immersed in the thallus, but with raised edges formed by the gemmiparous plates; urceolated (or resembling a short tube with a wide mouth), and covered with a thin coloured membrane; within, somewhat gelatinous, and of simple texture. *Thallus* crustaceous, uniform.

The generic name is derived from the Greek γυαλος, concave, in allusion to the shape of the apothecia. This genus includes only four or five species; one of which is the remarkable Lichen excavatus observed by Thunberg on the rocks at the Cape of Good Hope.

5. **Lecidea.** *Apothecia* circular, sèssile, covered with a coloured membrane; bordered by a regularly equal disk; within, of simple texture. *Thallus* varying; crustaceous, either uniform or figured; rarely foliaceous, and cloth-like or cottony.

This is an important genus, containing more than a hundred species, and embracing many of the small crustaceous lichens which ornament the hardest rocks, and which first begin to operate their disintegration. The genus is divided into three sections: 1. *Catillaria*, with the thallus crustaceous and uniform; 2. *Lepidoma*, with the thallus crustaceous, figured, and somewhat leaf-like; and 3. *Crocynia*, with the thallus figured, and cloth-like or cottony. In the first section occur Lichen immersus, which is found sunk on the surface of our limestone rocks, and of the chalk-cliffs of England; the well-known and beautiful variety of Lichen atrovirens, called L. geographicus, from its resemblance to a coloured map,—a plant which is found at the highest elevations, and which terminates the vegetation on Chimborazo; L. Dicksonii, named in honour of Mr. Dickson of Covent Garden, and found by him on the Scottish mountains; and L. sanguinarius, remarkable for the bright red which the apothecia present when cut with a knife, or which they ultimately acquire when they spontaneously open. As examples of the second section, may be mentioned L. canescens, luridus, and leucophæus of British authors. Of the third section, the only species is L. gossypinus of Swartz, found on the Blue Mountains of Jamaica.

6. **Gyrophora.** *Apothecia* circular, sessile, spirally plaited; with a border; covered with a coloured membrane (black); within, of simple texture. *Thallus* leaf-like, membranaceous, peltate, or supported by a central stalk.

Lichen polyphyllus, proboscideus, and pustulatus, of Linnæus and of English authors, afford examples of this genus.

7. **Calycium.** *Apothecia* cup-shaped, with a stalk (rarely sub-sessile), and surrounded by a border; filled with a powdery mass, which forms at first a flattish and afterwards a somewhat globular disk. *Thallus* crustaceous, uniform.

This genus is divided into three sections: 1. With sub-sessile cups, *Acolium*; 2. Cups stipitate or supported on stalks, and furnished with a border, *Phacotium*; and 3. Cups stipitate, the disk sub-globular, almost inclosing the border, *Strongylium*. In most of the species the crust is extremely thin, and in some it is scarcely perceptible. Several of those with stipitate cups have, by different authors, been referred to the genera Mucor and Trichia; for instance, Calycium aciculare of Acharius is the Trichia fulva of Withering.

8. **Opegrapha.** *Apothecia* of an oblong shape, sessile, covered with a coloured membrane (black); with a straitened disk, inclosed by a border; within, of simple texture. *Thallus* crustaceous, membranaceous, rough, or granulated, uniform.

The generic name implies a similarity to written characters. There are two sections: *Hysterina*, having oval or elliptical apothecia; and *Alyxorina*, having them of a linear shape. The former may be illustrated by a reference to the Lichen simplex of the Rev. Hugh Davies, in *Lin. Trans.* vol. ii. Of the latter, a new species, named O. tridens, has been observed by Mr. Turner of Yarmouth.

B. HETEROGENEI.

9. **Graphis.** *Apothecia* linear, immersed, or surrounded by a spurious border of the thallus; the perithecium forming an interior border, within which a naked disk is seen, being the upper part of an elongated nucleus, which is cellularly striated within. *Thallus* crustaceous, membranaceous, or rough and granulated; uniform.

The species of this genus have perhaps a still more striking resemblance to written characters. One of them is the Lichen scriptus of Linnæus, which is common on the smooth bark of many of our trees, particularly oaks, elms, and birches. A variety of this species is remarkable for having the apothecia so arranged, as to represent not unaptly many letters of the Hebrew alphabet.

10. **Biatora.** *Apothecia* circular, immersed, presenting a concave naked disk, encircled by the perithecium, which forms a margin; nucleus compressed, of nearly uniform texture within, and very slightly marked with cellular divisions. *Thallus* crustaceous, uniform.

Of this genus there is only a single species hitherto known, B. turgida, which inhabits rocks in the elevated woods of Switzerland. It has much the habit of a Lecidea; but is distinguished by possessing a perithecium and nucleus. The name is derived from the Greek word βιατος, signifying a small jug or bowl.

11. **Verrucaria.** *Apothecia* subglobular, partly immersed in the thallus; covered by a double perithecium, the exterior one cartilaginous (black), set with papillæ, which at maturity exhibit small perforations; nucleus subglobular, cellular, the cells including vesicles of a concatenated form. *Thallus* crustaceous, membranaceous, somewhat granulated or powdery; uniform.

Nearly fifty species of Verrucaria are described by Acharius. They are divided into five sections, distinguished by the nature of the thallus: 1. *Lejophloea*, with the thallus cartilaginous and smooth; 2. *Blennorina*, subgelatinous; 3. *Lithoicea*, crustaceous; 4. *Conizæa*, crustaceous and powdery; and, 5. *Inoderma*, with the thallus somewhat sponge-like. Few of the species which fall under this genus have been described by British authors. Two, however, may be mentioned, Lichen tesselatus of *Eng. Bot.* t. 533, and L. fuscellus of Turner, in *Lin. Trans.* vii. p. 90. Of the 5th section, it may be added, Sphæria byssacea of Withering, affords an example.

12. Endocarpon. *Apothecia* globular, included in the thallus, each covered with a membranaceous, diaphanous, simple perithecium, with a small (blackish) perforation, marked by an indistinct border, and projecting from the surface of the thallus; nucleus globular, commonly furnished with cells. *Thallus* either crustaceous and uniform, or somewhat cartilaginous, leaf-like, and lobed.

Among the foliaceous species of Endocarpon, may be mentioned, Lichen miniatus, (E. miniatum, Ach.) L. amphibius, (E. complicatum, Ach.), and L. aquaticus, (E. Weberi, Ach.) of English authors.

13. Trypethelium. *Apothecium* hemispherical, sessile, (coloured), including several thalami, or smaller apothecia; covered with a thick (black) perithecium, terminating above in a small prominent perforation; the apothecium including the others within its proper substance, which is distinct from that of the thallus; the nuclei globular, and furnished with cells. *Thallus* membranaceous, and somewhat cartilaginous; uniform.

Only two species of Trypethelium have been described; one found on American, and the other on African trees. The common apothecium of this genus, producing subsidiary apothecia, is evidently a distinct organ, and should be distinguished by an appropriate name. In the next two genera, taken from a recent paper of Acharius, it is called Verruca.

14. Glyphis. *Apothecia* subcartilaginous; roundish, or somewhat elongated; naked above, flattish, channelled; homogeneous within; many crowded within a single wart-like organ, (Verruca,) formed of a coloured substance (black), proper to itself, or distinct from the thallus. *Thallus* crustaceo-cartilaginous, flatly expanded, and adhering closely; uniform.

This genus has been proposed by Acharius, since the publication of the *Lichenographia Universalis*, in a communication to the Linnean Society, which is printed in the 12th volume of their *Transactions*. It is allied to Trypethelium, in having a peculiar wart-like receptacle or verruca, containing several apothecia; or in having a common apothecium including several partial apothecia; but it is distinguished from that genus by the absence of perithecium, porous opening, and nucleus. The species of Glyphis are found chiefly on the bark of tropical trees.

15. Chiodecton. Many *apothecia* crowded within a single convex or spherical wart-like organ, (verruca,) formed of a peculiar substance, distinct from the thallus, (white); the apothecia somewhat powdery, roundish, (black,) heaped together within the body of the verruca, while on its surface appear elevated dots. *Thallus* crustaceo-cartilaginous, flat, adhering closely, uniform.

This genus, which is nearly allied to the former, has also been constituted by Acharius since the publication of the *Lichenographia*, and communicated through the medium of the *Linnean Transactions*. Only two species have been described: both are found on American trees; one on the bark of a remarkable tree, Bonplandia trifoliata, better known perhaps by the name of Angustura.

Class II. COENOTHALAMI.

A. Phymatoidei.

16. Porina. *Apothecia* wart-like, formed of the substance of the thallus, including many thalami, or smaller receptacles, covered with a very delicate transparent perithecium, punctured above with small perforations; nuclei subglobular, furnished with cells and vesicles. *Thallus* cartilagineo-membranaceous, and somewhat crustaceous; uniform.

Of this genus, Lichen pertusus of British authors is an example.

17. Thelotrema. *Apothecia* wart-like, formed of the thallus, hollowed, with a border; each including a single thalamium, or smaller receptacle, encircled by a membranaceous perithecium, ultimately bursting above; nucleus compressed; within, of simple texture, and acquiring somewhat of a striated appearance from the regular disposition of the gongyli. *Thallus* cartilagineo-membranaceous, and somewhat crustaceous; uniform.

For illustration of this genus, Lichen inclusus, and L. exanthematicus, of *English Botany*, may be referred to.

18. Pyrenula. *Apothecia* wart-like, formed of the thallus, including a single subordinate receptacle or thalamium, covered with a thick (black) cartilaginous perithecium, which is prominent, and terminates in a papilla; nucleus globular, and furnished with cells. *Thallus* crustaceous, or cartilagineo-membranaceous; uniform.

This genus contains very few species, and is nearly allied to Verrucaria and Porina. Lichen pertusus of Thunberg is a Pyrenula; but the *pertusus* of other authors is a Porina.

19. Variolaria. *Apothecia* wart-like, formed of the thallus, (every where rough or scab-like;) with an indistinct border, including and concealing a compressed gemmiparous plate, divided into cells, but destitute of a perithecium. *Thallus* cartilagineo-membranaceous, or crustaceous; uniform.

Lichen fagineus of Linnæus, which is pretty common on the bark of our beech and hornbeam trees, is a variety of Variolaria communis of Acharius. Lichen lacteus, Lin. is likewise a Variolaria.

20. Sagedia. *Apothecia* wart-like, formed of the thallus, covered above with a coloured membrane; marked with a disk-shaped depression, and concealing a gemmiparous plate, which is shaped like a nucleus, immersed in the substance of the thallus, and of simple texture within. *Thallus* crustaceous, uniform.

Only six or seven species of this genus are known;

they are small, and peculiar to hard rocks. One species, S. rufescens, has been observed only on the sand-stone rocks of England, where it was detected by Mr. Turner. The name is derived from σαγη, a shield, the apothecia greatly resembling small shields,—which might be said of several other genera.

B. Discoidei.

21. **Urceolaria.** *Apothecia* circular, with a border formed by the thallus; the gemmiparous plate coloured, forming a disk of the apothecium, having a proper border, or being elevated on the circumference, somewhat urceolate, and immersed in the substance of the thallus; within, of a striated appearance, and furnished with cells. *Thallus* crustaceous and uniform; sometimes granulated or powdery.

This genus is divided into two sections. 1. *Aspisteria*, in which the disk has no distinct border. To this section belong Lichen lacustris of Withering; and L. cinereus, Lin. a minute but common species, which often gives bare hard rocks a greyish appearance. 2. *Amphiloma*, in which the border both of the apothecium and the disk is distinctly raised. Of this division, Lichen scruposus, of *Eng. Bot.* and L. calcarius, Lin. (L. cinerascens of Withering,) are examples.

22. **Lecanora.** *Apothecia* circular, thick, sessile, formed of the thallus; gemmiparous plates coloured, forming plano-convex disks of the apothecia; encircled by, but not in immediate connection with, elevated unequal borders of the thallus; within, striated, and furnished with cells. *Thallus* crustaceous, tartar-like; uniform, or somewhat lobed.

This extensive genus, of which Acharius describes above 130 species, is divided into three sections. 1. *Rinodina*, with a uniform crustaceous thallus; as in Lichen ater, L. coarctatus, and L. Turneri, of *Eng. Bot.* L. quadricolor and coccineus of Dickson, L. ventosus, Lin.; and the well-known dye lichens, L. parellus, from which litmus is prepared; and L. tartareus, which affords the cudbear of the west of Scotland. 2. *Psoromæ*, (Plate LXXV. Fig. 4. b.) with a figured thallus, which is imbricated or squamous. Of this section, the beautiful Lichen decipiens may be mentioned as an example; and likewise L. crassus of Hudson, and L. candelarius of Linnæus, with the shredded frond of which "golden candles" are, in some countries, made for high festivals. 3. *Placodia*, with a flat crustaceous thallus, stellated or lobed on the circumference; as in Lichen gelidus, or L. Heclæ of *Flora Danica*, L. flavicans of Withering, and the small but elegant L. fulvus of Dickson.

23. **Roccella.** *Apothecia* circular, closely and wholly attached to the thallus; gemmiparous plates forming plano-convex disks to the apothecia, encircled with sessile borders formed by the thallus; covering globular but compressed masses, consisting of two layers, the upper transparent and rather gelatinous, the under blackish and compact, including nests of naked gongyli. *Thallus* cartilaginous, and somewhat leathery; round or thread-shaped, also flat and shrub-like.

To this genus belongs the celebrated dye lichen, L. roccella, Lin. (Roccella tinctoria, Ach.) Fig. 4. a. It grows on the sea rocks of Portland island, but is rare in England. The only other species of this limited genus hitherto described, are the Lichen fuciformis, Lin. and L. fucoides of Dickson, which occur on maritime rocks in the south of England, and in the Channel islands.

24. **Evernia.** *Apothecia* circular, sessile, edges raised, and slightly bent inwards; gemmiparous plates forming concave disks, surrounded by a border of the thallus, which rises beyond them; within, of simple texture. *Thallus* branched or laciniated, cottony, or woolly; angular, sometimes compressed or flat.

This genus includes the well-known Lichen prunastri, Lin. which grows abundantly on our trees; and also L. vulpinus, Lin. which is considered as poisonous, and occurs sparingly on trees in this country. The generic name is taken from the Greek ευεργης, branched, in allusion to the ramification of the thallus.

25. **Sticta.** *Apothecia* circular, thickish, adhering closely to the thallus, to which they are attached by the centre, while they are otherwise free; gemmiparous plates flat, forming disks, encircled by borders of the thallus, which project beyond them. *Thallus* somewhat leathery and cartilaginous, foliaceous, forming large lobes; beneath, villose or woolly, and generally marked with pits or pores (cyphellæ), and mealy warts (soredia).

This genus takes in the Lichen pulmonarius, or lungwart moss, which is common on the trunks of old trees in this country; but neither the cyphellæ nor soredia are seen in that species. Lichen scrobiculatus, (verrucosus of Hudson,) and L. fuliginosus of Dickson, afford, therefore, better examples of Sticta. It may be noticed, that both the Sticta pulmonacea and S. scrobiculata are promiscuously denominated *aikraw* (oak-rag) by the peasantry in the lowlands of Scotland. Several spreading species, which cover the huge stems of tropical trees, also belong to this genus.

26. **Parmelia.** *Apothecia* circular, somewhat urceolate, membranaceous, fixed to the thallus by the centre, and free beneath; gemmiparous plate covering the whole of the apothecium, and almost concealing it, bent inward at the circumference; within, in some species of simple texture, in others celluliferous and striated. *Thallus* membranaceous or inclined to leathery, foliaceous and often stellated, lobed and laciniated; generally with fibrils on the under side.

This genus contains about sixty species, and includes some of the largest and most beautiful of the lichen tribe, and several of those which are employed by the Scottish Highlanders to tinge the woollen-stuffs which they manufacture. It is divided into three sections. 1. *Lobaria*, with a circular leathery frond, divided into broad flat lobes. Of this, Lichen glomuliferus of *Flora Scotica* may be mentioned as an example, while at the same time it may be referred to as an instance of the excellent talent for description possessed by Lightfoot. Lichen caperatus, sometimes used for dyeing wool of a yellow colour, likewise falls under this section; and to it may be added, L. perlatus; lætevirens or herbaceus of Hudson; olivaceus; and the common yellow lichen of walls, L. parietinus. 2. *Circinaria*, with the thallus of a membranaceous substance and stellated form. To this division belong Lichen omphalodes and L. saxatilis, which are very abundant in the Highlands of Scotland and Wales, and are much used as dye-stuffs; likewise L. membranaceus of Dickson; L. plumbeus of Lightfoot; L. fahlunensis and stygius, which are found on the mountains of Scotland; the very common L. stellaris; and

L. centrifugus of British writers, (Parmelia conspersa, Ach.) 3. *Physcia*, with the thallus somewhat membranaceous, and of a stellated form, but the extremities of the segments appearing as if inflated. Lichen physodes, Lin. aptly exemplifies this section.

27. Borrera. *Apothecia* circular, shaped like small cups or pedicles; gemmiparous plates forming disks, surrounded and embraced by an elevated border of the thallus, which is bent inwards; within, furnished with vesicles, or sometimes of simple texture. *Thallus* cartilaginous, branched, and laciniated, the laciniæ generally naked and channelled below, often ciliated.

This genus, named in honour of a distinguished English botanist, Mr. Borrer of Sussex, (who, it is understood, has been long engaged in preparing, conjointly with another eminent cryptogamist, Mr. Dawson Turner of Yarmouth, a *Lichenographia Britannica*), is well characterized by the beautifully fringed species L. ciliaris and L. tenellus of British authors.

28. Cetraria. *Apothecia* roundish, plano-concave, attached obliquely to the margin of the thallus, and therefore loose beneath, elevated and bent inward at the circumference; gemmiparous plate surrounded by a projecting border formed by the thallus; within, of simple texture, or slightly celluliferous. *Thallus* membranaceous, and somewhat cartilaginous, foliaceous, irregularly laciniated, smooth below.

The well-known Lichen Islandicus affords an example of this genus. To it also belongs L. nivalis, which grows on the summit of Ben Lawers in Scotland, but which has not there been found in fructification: from Acharius we learn, that the targets or apothecia are flesh coloured, with a finely scolloped border, formed by the thallus. L. juniperinus and glaucus of Linnæus are likewise Cetrariæ: The latter species, with the apothecia in a perfect state, (in which condition it is rarely found,) has been detected near Inverary, by a distinguished Scottish cryptogamic botanist, Mr. Robert Maughan, senior.

29. Peltidéa. *Apothecia* circular, flat; gemmiparous plates wholly above the thallus, and situated on appropriate small lobes, attached somewhat obliquely; surrounded by elevated borders formed by the thallus; within, of simple texture, or celluliferous. *Thallus* leathery or membranaceous, leaf-like; beneath, veined and woolly, with partial lobules bearing the apothecia.

This genus is well marked by the numerous small lobes of the frond, but is named from the proportionally large *peltæ* or targets (apothecia) with which these lobules are ornamented. The far-famed Lichen caninus, or ash-coloured ground liverwort, affords an example; and L. venosus, scutatus, horizontalis, and aphthosus of Linnæus, likewise belong to it.

30. Nephroma. *Apothecia* kidney-shaped, flat; attached to the under side of the frond, and on proper lobes; embraced by a raised thallus-border, except at the interior side or base of the lobe; within, of simple texture, and striated. *Thallus* leathery and membranaceous, leaf-like; beneath, smooth, or only slightly villose, with partial lobules producing the apothecia.

This genus is nearly allied to the preceding, being distinguished chiefly by the reniform appearance of the apothecium, or rather of the gemmiparous plate. It includes L. arcticus and antarcticus of Linnæus; and may be exemplified in L. resupinatus of our own country, the trivial name of which is taken from the circumstance of the apothecia facing downwards.

31. Dufourea. *Apothecia* circular, terminal, supported each by a tubular branch of the thallus, which forms a border to it; fixed by the circumference, beneath free; gemmiparous plates forming plano-convex disks, within of simple texture. *Thallus* membranaceous and soft, branched, roundish, within fistular and cottony.

This genus contains only two or three species, and these are natives of rocks and trees in Africa. It is named in honour of M. Dufour, the most distinguished lichenologist of France, and who intends to publish a *Lichenographia Gallica*, including the species found on the Italian Alps, and on the Pyrenees.

C. Cephaloidei.

32. Cenomyce. *Apothecia* roundish, convex, like the capitula of mosses, without a border fixed at the circumference, beneath free, hollow within, covered; gemmiparous plate covering the whole surface of the apothecium, reflexed at the edges, within of simple texture. *Thallus* cartilaginous and somewhat crustaceous, leaf-like and laciniated, rarely uniform, producing fistular cup-like processes (podetia), bearing the apothecia on their tips.

This is an extensive genus; and it is difficult accurately to discriminate the species, owing to the great variableness both of the thallus or frond, and of the podetia or tubes. The very common Lichen pyxidatus, and L. cocciferus of Linnæus may illustrate it; and these and some others readily attract the eye by the bright red of the tubercles. Many of the species inhabit sterile moorish grounds; of these, the well-known rein-deer lichen, (L. rangiferinus, Lin.) is the most important. (Fig. 4. c.) In different species the frond is divided so as to resemble the branching of the antlers of various kinds of deer. Lightfoot describes an *alcicornis*, and Acharius has added both a *damæcornis* and a *cervicornis*. Other species of Cenomyce, which occur pretty frequently in this country, are, L. uncialis and cornutus of Linnæus; L. furcatus of Hudson; and L. vermicularis of Dickson. The genus is divided into four sections. 1. *Phyllocarpa*, with the frond foliaceous, lobed and tiled, and very short and indistinct podetia. 2. *Cladonia*, with the frond foliaceous and laciniated, and the podetia cup-shaped. 3. *Helopodia*, frond laciniated and imbricated, podetia cylindrical and fistular, terminated by apothecia resembling minute fungi. 4. *Pycnothelia*, with the thallus crustaceous and uniform.

33. Bæomyces. *Apothecia* circular, convex, shaped like capitula, without borders, solid, sessile; clothed with the gemmiparous plate, which is reflexed at the circumference, and of simple texture within. *Thallus* crustaceous, uniform, with short, soft, solid podetia, supporting the apothecia.

There are only three or four species of this genus. The generic name alludes to the circumstance of the tubercles resembling small fungi, or lycoperdons; being derived from βαιος, small, and μυκης, a mushroom. Lichen ericetorum and L. fungiformis of Withering may be noticed as examples: the former is Bæomyces roseus, and the latter B. rupestris of Acharius.

34. Isidium. *Apothecia* circular, in a great measure formed of the gemmiparous plate; at first almost included within the apex of the podetium, and bordered by it; afterwards becoming prominent, thick, hemispherical; beneath flat, and sessile; within, of simple texture. *Thallus* crustaceous or tartar-like, uniform, furnished with solid short podetia (papillæ of some authors), some barren, others bearing a gemmiparous plate, or constituting apothecia.

The name of this genus has been bestowed, on account of its general resemblance to the coral called Isis by Linnæus; and Lichen corallinus may be mentioned as an example. Only eight species are described by Acharius; and one of these, L. oculatus (Isidium ocellatum, Ach.) he received from our countryman Dickson, nor does it appear to have been found elsewhere than on the rocks of Scotland.

35. Stereocaulon. *Apothecia* solid, sessile, with a border; at first turban-shaped, but afterwards acquiring a hemispherical or almost globular form, covered above; the gemmiparous plate ultimately dilated, and extending over the border, reflexed; within, of simple texture, somewhat striated. *Thallus* shrubwise branched, cylindrical or roundish; within, rather of a woody texture, solid; with a crustaceous bark, set with small granulations.

The solid stem (στερεως καυλις) gives name to this genus. It may be exemplified in Lichen paschalis of Linnæus, which grows on the rocks of the Highland districts of this country.

36. Sphærophoron. *Apothecia* somewhat globular, terminal on the branches of the thallus, of which they are formed; at length bursting on one side, when they are seen to include a mass or ball (of a dark colour), which soon falls into powder. *Thallus* shrublike, branched, cottony within, rather solid, covered with a cartilaginous bark.

This is a very well marked genus, distinguished by its spherical parts of fructification (σφαιρα φορος). Only three species are described by Acharius. Lichen fragilis, Lin. (Sphærophoron compressum, Ach.) which is not uncommon on our upland heaths, and which much resembles a small coralline, and L. globiferus, Lin. are two of these.

37. Rhizomorpha. *Apothecia* rather globular, terminal, or on the points of the branchlets, filled with a somewhat gelatinous mass; of simple texture. *Thallus* branched, filiform, prostrate or creeping, cottony within, clothed with a cartilaginous bark.

This *root-shaped* genus includes several plants which have commonly been referred to the genus Clavaria by English writers, and which particularly have been considered as varieties of Clavaria hypoxylon.

Class III. HOMOTHALAMI.

38. Alectoria. *Apothecia* circular, thickish, sessile, with a border; afterwards becoming convex, and the border nearly disappearing; wholly formed of the thallus. *Thallus* branched, with filiform branchlets (lorula), pendulous or prostrate; within, fistulous and of cottony substance, with a cartilaginous bark.

The well-known Lichen jubatus of Linnæus, or horsetail lichen, affords an example of Alectoria, a name which is taken from the Greek word for *hair.*

39. Ramalina. *Apothecia* circular, thickish, somewhat peltate or supported on central pedicles, flat, with a border; wholly formed of the thallus. *Thallus* branched and laciniated, in tufts; within, rather solid, but composed of cottony substance, with a cartilaginous bark.

This genus includes the well-known and common Lichen fraxineus, fastigiatus, and farinaceus of Linnæus, which are abundant not only on the oak, the ash, and other forest trees, but often infest orchards. Lichen calicaris, Lin. (Ramalina scopulorum, Ach.), which clothes many of our rocks near the sea, likewise belongs to it. The generic name is derived from the Latin *ramale*, a dead twig, the plants having been considered as resembling, or perhaps as denoting, decayed branches.

40. Cornicularia. *Apothecia* circular, obliquely peltate; at first, with scarcely a perceptible border, but afterwards becoming dentate and reflexed; wholly formed of the thallus. *Thallus* branched, shrub-like, slender; within, somewhat solid, of cottony substance, with a hard cartilaginous bark, rendering the plant rigid and rather fragile.

Lichen corniculatus of Flora Scotica (Cornicularia tristis, Ach.), and L. hispidus (C. spadicea, Ach.), which are found on rocks in the Highland districts, as well as L. ochroleucus, which grows on the highest mountains of Scotland, afford examples of this genus.

41. Usnea. *Apothecia* circular, peltate, very broad, flat, without a border, but on the circumference somewhat ciliated, or set with hair-like fibrils (rarely almost naked); wholly formed of the thallus, and of cottony substance within. *Thallus* branched, filiform, with a tough thread-like fasciculus of little ducts running along the centre, covered with a cartilagineo-crustaceous bark, rather brittle when dry.

Lichen plicatus, floridus, and barbatus of Linnæus, are examples. These grow generally on old trees, and in thick shady woods; Lichen plicatus, indeed, is often particularly distinguished by the name of Tree-moss.

42. Collema. *Apothecia* circular, immersed, sessile, (rarely with a sort of pedicle), bordered, urceolate, flat, entirely formed of the thallus. *Thallus* varying in shape, wholly of the same gelatinous kind of substance; when dry, becoming hard and cartilaginous.

The generic name is derived from κολλα, gluten. The species are pretty numerous; they vary greatly in aspect, and are therefore distributed into no fewer than seven sections. 1. *Placynthium*, with a crust-like thallus, as in Lichen niger, Lin. 2. *Enchylium*, with the thallus imbricated, composed of small lobes, and roundish, as in L. cristatus, Lin. (Collema pulposum var. Ach.) and in L. fascicularis. 3. *Scytinium*, thallus foliaceous, somewhat tiled, the lobes distinct, thick, turgid; as in L. palmatus of Hudson. 4. *Mallotium*, foliaceous, with the lobes rounded, and fibrils on the under side; as in L. saturninus of Dickson, and L. Burgessii of Lightfoot. 5. *Lathagrium*, foliaceous, with the lobes membranaceous, broad, loose, of a blackish green colour; as in L. nigrescens, Lin. (L. vespertilio of Lightfoot). 6. *Leptogium*, foliaceous, with the lobes of a very delicate diaphanous substance, generally glaucous; as in L. tremella of English authors, (Collema lacerum, Ach.) 7. *Polychidium*, with the thallus very finely branched and laciniated; as in the minute and elegant Lichen tenuissimus of Dickson, and also in L. muscicola of the same author.

(Appendix.) ATHALAMI.

43. **Lepraria.** No apothecia. The gongyli (if such they be) naked, loose, collected in little heaps. *Thallus* crustaceous, powdery or leprous-like, uniform; in general, composed almost entirely of gongyli or propagula.

Byssus candelaris of Linnæus, or Lichen flavus of English authors, may exemplify this doubtful genus.

Such is the arrangement adopted in the *Lichenographia Universalis* of Acharius, with the additions suggested by the author in the 12th volume of the *Linnean Transactions*. The greatest pains have evidently been bestowed on the execution of the work. As a proof of this, it may be noticed, that the generic characters are all minutely and accurately illustrated by figures, in as far at least as these characters depend on the apothecia or shields. These figures are usually magnified, and represent perpendicular, and sometimes also horizontal sections, so as to afford the clearest possible explanation of the descriptions. But the generic characters depend not only on the situation, shape, and structure of the shields, but on the general habit and form of the lichen. It has been objected, we believe, that some of the characters of the genera are not sufficiently obvious; that, so far from being so, unpractised eyes might find difficulty in detecting *specific* differences where they ought to look for *generic*. To those, however, who are somewhat accustomed to minute discrimination, this difficulty in a great measure vanishes; and from a single perfect specimen of any species, the genus may generally without hesitation be determined, while the similarity in external habit very commonly leads to the association of the other species of the same genus. In point of fact, too, the principal generic characters of Acharius are taken from the external parts of the plant, which are pretty easily distinguished, although it necessarily happens that these are often small, and must be examined with a magnifying glass. The difficulty attending the multiplication of genera, it may be remarked, consists more in appearance than in reality. *Genera*, it must be remembered, are necessarily artificial divisions, *species* only being natural. The forty-three genera of Acharius may be considered as equivalent to as many sections of the overgrown genus Lichen of Linnæus; and thus the principal objection will resolve into the additional tax on the memory of the botanist, who must treasure up so many more generic names, some of them not a little uncouth. While Acharius has increased the number of genera, however, he has greatly reduced the number of *species* described by preceding writers. This was to be expected, as the necessary result of a painfully careful examination of the different appearance of the same plants in their early and advanced stages, and of the same species taken from different habitats,—from a rock or from a tree, from a shady or an exposed situation. Colour, it is well known, is peculiarly liable to variation, so that it cannot alone be depended on as a character in describing natural bodies. But colours are less liable to change in cryptogamic than in phænogamous plants, and they are therefore with propriety occasionally noticed by Acharius; still, however, when colour is mentioned as a character by this cautious investigator, it is always in a subsidiary way, as indicated by printing within parentheses. In the *Lichenographia Universalis*, the synonymy is not nearly so ample as in the *Methodus Lichenum*; but the name bestowed by the discoverer, or by the author who first described the species, is commonly given; and where species have been represented in engravings, the best figures are referred to.

Dr. Wahlenberg of Stockholm, in his *Flora Lapponica*, 1812, has also divided lichens into three classes. I. *Athalamæ*, containing two genera, Lepraria and Variolaria. II. *Homothalamæ*, containing four genera, Lichen, Peltidea, Baeomyces, and Endocarpon. III. *Heterothalamæ*, containing six genera, Verrucaria, Opegrapha, Lecidea, Gyromum, Calicium, and Sphærophoron. In this way, Wahlenberg confines the number of genera to twelve; but the limited scope of his work, being the description of the plants of Lapland only, may have prevented him from introducing some other genera, which, had his subject led him to examine them, he might otherwise have felt inclined to adopt. On account of the highly respectable character of this author, it deserves to be noticed, that, in the work just named, he mentions that his scheme for the arrangement of lichens was composed in 1801, and at that time communicated to Acharius,—evidently leaving the reader to infer, that this eminent lichenologist had availed himself, without due acknowledgment, of his communication.

Habitats of Lichens.

The general distribution of lichens has already been slightly touched on. It may here be observed, that certain species show an attachment for particular kinds of rocks, in the same way as the more perfect plants evince a predilection for different varieties of soils. The hardest masses of granite and gneiss on the Scottish mountains are the favourite residence of Lecanora gelida, Lecidea petræa, silacea, lapicida, sulphurea, and atrovirens, Parmelia fahlunensis, Verrucaria glaucina, Opegrapha petræa, and Gyrophora proboscidea. Lecanora fusco-atra var. dendritica has been observed on pure rock-crystal. The porphyry rocks are preferred by Lecidea pustulata and confluens, Parmelia ciliaris and furfuracea, and Gyrophora deusta. The mica-slate rocks seem to be the choice of Cornicularia tristis and exilis, Gyrophora polyphylla, and of the var. *frigida* of Lecanora tartarea, which often appears branched, from its twisting about mosses and remains of jungermanniæ: the clay-slate of Lecidea Dicksoni and cupularis, Lecanora decipiens, and Bæomyces rupestris. The claystone porphyries and different varieties of trap-rocks are the favourite habitats of numerous species, such as Lecidea fusco-ater, Urceolaria scruposa and cinerea, Lecanora tartarea, Parmelia saxatilis and caperata. Sandstone, especially if near the sea, is generally selected by Ramalina scopulorum: Lecanora parella and atra are likewise very commonly found upon it. Limestone is preferred by Lecidea immersa, Collema nigra, Verrucaria muralis, Urceolaria calcarea, and Thelotrema exanthematica. All of the lichens now mentioned, however, are occasionally to be found on rocks of very different geognostic and mineralogical characters, their growth being much influenced by the circumstances of elevation and exposure.

In like manner, it may be remarked, certain species seem attached to particular kinds of trees; but the same species grow on various sorts of trees, assuming a somewhat different habit on each kind, and to a certain extent acquiring different qualities. Thus, of the Variolaria communis of Acharius, we have four varieties, indicated by the trivial names *faginea*, *alnea*, *pinea*, and *abietina*, from their growing on the beech, the alder, the pine, and the spruce.

The most naked heaths form the favourite habitation of numerous species of Cenomyce. Coarse moist clay is preferred by some of the Peltideæ, as P. venosa and horizontalis. The more gelatinous lichens often support themselves by means of decaying mosses, around which they form incrustations, as may be seen in Collema pulposum, tenax, and tremelloides, and in Lecidea muscorum. Some lichens grow on stones under water, as Collema fluviatile, and C. flaccidum var. β. Several species of Rhizomorpha inhabit the galleries of deep mines, such as those of Leadhills, particularly R. spinosa (Clavaria hypoxylon of most English authors), and R. dichotoma and subterranea. A few small species take up their abode, parasitically, on the musci hepatici, and even on other lichens; thus, var. β of Lecidea cinereo-fusca has been observed on jungermanniæ, and Calicium stigonellum (Lichen gelasinatus of Withering) on the crust of Porina pertusa.

Uses of Lichens.

It now remains only to give some account of the uses of lichens. Here no assistance is to be derived from the labours of Acharius, his writings being purely botanical. Linnæus, Hoffman, Georgi, Lightfoot, Withering, and others, make amends; and the essays on this subject by Watson, by Amoreux the younger, by Willemet, Westring, and Proust, might afford materials for a longer dissertation than would be suitable for this place. In the course of treating of their uses we shall notice the few observations which appear to have been made by chemists on the constituent parts of lichens.

Lichens are of great utility in the general economy of nature, although their operation is slow, and almost imperceptible. The largest oaks of the forest, and most ancient pear trees of the orchard—trees which endure for centuries—at length become "*mossed* with age," and more frequently owe their destruction to the silent attacks of parasitical lichens, especially of the larger branched kinds, than to the ravages of storms. But it is not merely on the "monarchs of the wood" that lichens exert their influence. Many species, as we have just seen, vegetate upon the barest and hardest rocks: these, by their decay, prepare a suitable nidus for the smaller frondose mosses. The mosses, in their turn, afford sufficient soil for rock plants of a larger size, such as stone-crop, or sheep's-fescue; and thus the rocks at length become covered with herbage, or even with shrubby and arboreous plants. In this way, we may distinctly trace to the vegetation of the humble crustaceous lichen, the commencement of one means of that gradual but never ceasing disintegration or decay, which is wearing down the densest and loftiest pinnacles of the earth. Meantime, lichens tend to enliven and variegate rock scenery, by "bestowing tints of a delicate pea-green and primrose, which (to use the words of Ann Ratcliffe) it is not necessary to be a botanist to admire."

Food to Animals.—In the extreme northern countries of Europe, the ***branched coralline lichen*** (Cenomyce rangiferina,) is highly important in rural economy, as affording the principal food of the rein-deer—animals in which consist the whole riches of the inhabitants. In Lapland, as we learn from Linnæus, plains of several miles in extent are often completely covered with this lichen; and in places where no other plant will even take root, this thrives and becomes luxuriant. These dreary wastes—these "terræ damnatæ," as a naturalist of a lower latitude has styled them—are the Lapland fields and fertile pastures. On these the rein deer feed during winter. By a kind provision of nature, it happens that at this pinching season, when no other vegetable is to be had, the lichen, buried under the snow, is found in its most flourishing state. The rein-deer, tossing aside the icy surface-covering with their antlers, and scraping off the loose snow with their fore-feet, devour the lichen greedily, and even become fat upon it. When the proper lichen is deficient, some other species are resorted to by the deer, particularly Stereocaulon paschale, and the common *rock hair*, Alectoria jubata. In this country the rein-deer lichen is seldom found more than three or four inches high: in Lapland, however, it flourishes exceedingly, and is frequently from six to ten inches in height. In some districts of the north of Europe, it is collected like hay, and stored as provender for black cattle. In the mountainous districts of Upper Carniola, Cetraria Islandica is collected in quantities, and used for fattening cattle. Even in the southern states of America, particularly in Virginia, a species of lichen is gathered for winter food both for sheep and cows. This is the *necklace-moss*, Lichen articulatus, (which is L. barbatus in an advanced stage of growth, or Usnea barbata of Acharius.) Many species of lichen are eaten by goats, and evidently afford a grateful food to them.

Only two or three species of lichen have hitherto been employed by man as articles of food. Several species have, at different times, acquired celebrity in the cure of diseases. The most important and valuable use of lichens, however, is in the arts, particularly in dying.

Food to Man.—The principal species which affords food to mankind is the ***Lichen Islandicus***, or Eryngo-leaved liverwort, (Cetraria Islandica, Ach.) This, as implied in the trivial name, is abundant in Iceland, where no kind of grain can be ripened. It is collected in the summer, and, when dry, ground into meal or flour, of which bread and gruel, or pottage, are made. It is sometimes also put whole into broth, or is boiled in whey, till it be converted into a jelly. In general, it is either previously steeped for some hours in warm water, or the water of the first boiling is rejected, in order to remove a part of the bitter extractive matter, which, if left, produces a disagreeable taste, and is apt to prove purgative. It has often been recommended as a light and delicate article of food for persons of a phthisical habit, or subject to catarrhal complaints; and for this purpose it is yearly imported in small quantities into England. In the *Journal de Physique*, M. Proust particularly mentions its properties as an esculent substance. One pound weight of the dry lichen in powder, weighed, when boiled for a quarter of an hour, and well drained, about three pounds; and the same quantity of the dry lichen was found sufficient for making no less than eight pounds of soup; and this soup was so rich, that, on cooling, it turned to a tremulous jelly. The lichen, simply boiled, possesses a sort of membranous elasticity, on account of its containing a considerable proportion of insoluble starchy matter.

One hundred parts of dried lichen afforded to M. Proust, of

Bitter extractive	3
Matter soluble in hot water	33
——— insoluble	64
	100

The soluble matter, he remarks, is nearly allied to starch, and like it, is precipitated by infusion of galls: it differs from it, however, in not being glutinous, and in the solid matter of the jelly contracting and separating from the fluid, as curd does from whey. The insoluble matter, on the other hand, has much analogy with gluten.

To this account of M. Proust, it may be proper to subjoin the result of an analysis performed by Berzelius, as detailed in the 90th volume of the *Annales de Chimie*, especially as this analysis is probably the most rigorous and accurate which has hitherto been made of any species of lichen. From 100 parts he obtained the following constituents:

Syrup	3.6
Bitartrate of potass, with a little tartrate and phosphate of lime	1.9
Bitter principle	3
Green wax	1.6
Gum	3.7
Extractive colouring matter	7
Starch	44.6
Insoluble starchy matter	36.6
	101.6

A substance containing 80 parts in the 100 of starch, or starchy matter, and small portions of syrup and gum, must be highly nutritious; and Proust remarks, that nature can scarcely furnish a more excellent article of food. In general it retains a slightly bitterish taste, resembling the flavour of weak succory water: but if seasoned with sugar and lemon-peel, and eaten with butter or oil, it is said to form a very palateable dish. Sir George Mackenzie, in his *Travels in Iceland*, mentions that this lichen was mixed with chocolate made for breakfast, at the house of Dr. Clog, a physician near Reikiavig, but that he could not, from the taste of the beverage, have detected the presence of the lichen. Proust recommends it as a very convenient antiscorbutic vegetable on long sea voyages, and as a home article of diet in times of scarcity. Liljeblad, it may be added, has published a separate tract, strongly recommending its use in Sweden, when visited with unfavourable seasons and bad harvests.

The Iceland moss has scarcely any perceptible flavour: indeed very few of the lichen tribe affect either the sense of taste or of smell. A small species (Lecidea aromatica, Ach.) first described by Mr. Turner of Yarmouth, is said to possess a slightly aromatic taste; and Variolaria amara and Borrera furfuracea are remarkable for their bitter qualities. From Mr. Hooker's work on Iceland, we learn, that Gyrophora hirsuta of Acharius, is considered by M. Paulsen as forming an article of food greatly superior in quality to the Cetraria Islandica. It is produced only on lofty crags; and whether it can be collected in considerable quantities is not mentioned. It is, however, a pretty common species on the gneiss rocks of Sweden. On the same authority, it may be added, that Gyrophora cylindrica is used as food in Iceland in times of scarcity: this species, we may notice, was observed on the mountain of Goatfield in Arran, by Mr. Lightfoot; and by him described under the name of Lichen crinitus.

A lichen is noticed by Professor Pallas, in his earlier *Travels*, as growing on the calcareous mountains of the Great Desert of Tartary, the thick coriaceous crust of which is eaten by the wandering tribes: It is described by Acharius under the name of Urceolaria esculenta.

Gmelin informs us, that in Siberia, the lungwort lichen, Sticta pulmonacea, is used, in the making of ale, as a substitute for hops; and Georgi notices it as an edible species, along with Pamelia physodes, Usnea plicata var. hirta, and Ramalina farinacea. These lichens, when boiled, yield a yellow mucilage, nearly insipid; and, when eaten with salt, are said to form a tolerable food. They all give out a portion of resin to alcohol; but the taste of this is not discernible in the water in which they are boiled. Some others of the branched and filamentous lichens, such as Ramalina fraxinea and fastigiata, and Usnea barbata, have been examined chemically by Berzelius, and found to be characterized by the presence of a species of starch possessing several peculiar properties. Probably these also might be employed as food.

Medicine.—Several of the lichens were formerly celebrated as specifics in the cure of diseases. The common *cup-moss*, (Lichen pyxidatus, or Cenomyce pyxidata, Ach.) was long regarded as an infallible nostrum for the hooping-cough. The common *ground liverwort* (Lichen caninus, or Peltidea canina, Ach.) received its trivial name on account of the fame it had acquired as a specific for the bite of a mad dog. Even the celebrated Dr. Mead, in his History of Poisons, eulogized this medicine, and declared that it had never failed, during thirty years experience, in averting the terrible consequences which result from the bite of this animal when in a rabid state; but at the same time he mentioned, that copious bleeding was to be conjoined. The tree lungwort, or *oak-lungs* (Lichen pulmonarius, or Sticta pulmonacea, Ach.) was renowned in former times, for relieving pulmonary complaints. In those days, nothing was more common among practitioners who trusted in simples for the cure of diseases, than endeavouring to find a plant possessed of some fancied resemblance to the part of the body affected: the wrinkled and reticulated frond of this lichen having some similarity to the surface of the human lungs, there remained no question of the propriety of administering it for disorders of these organs. It is scarcely necessary to add, that it has now completely lost its fame as a specific. From the experiments of Georgi and Amoreux, however, it appears, that this species possesses a portion, equal to one-eighth of its substance, of a reddish gum, having a slighly bitter taste: it is one of those, therefore, which may deserve the attention of the pharmacologist. The *Iceland moss*, as already hinted, has been recommended in incipient consumptive cases in this country, and a *Decoctum Lichenis Islandici* has a place in the *Edinburgh Pharmacopœia*. It is generally considered, however, as scarcely otherwise useful, than as affording a light nourishing diet. In Iceland and in Sweden it is much employed as an evacuant in the spring season. Dr. Withering tells us, that the country people in England make an infusion of Lichen aphthosus (Peltidea aphthosa, Ach.) in milk, and give it to children affected with the thrush, (aphthæ in the mouth,) and that, in large doses it destroys worms, by exciting purging and vomiting. Linnæus informs us, that the Laplanders apply a bandage composed of *tree moss*, (Usnea plicata, Ach.) to their feet, when excoriated with travelling, and that they find great benefit from this kind of cataplasm, arising probably from the stiptic quality of the plant. According to Pontoppidan, the yellow filamentous lichen, (Evernia vulpina,) is so poisonous, that it is employed for killing wolves, a carcase of some animal, smeared and stuffed with the powder of it, mixed with pounded glass, being set as a bait. It may be remarked, that a lichen, said to possess the active and powerful properties of a poison, might deserve further examination, as more likely to prove useful, when skilfully regulated by the physician, than such species, as have not attracted notice by exerting any remarkable energy.

Perfumery.—Lichens have for a long time been employed in *perfumery*. It is now impossible, perhaps, to determine with certainty what the *usnea* of the ancients was, or whether it even belonged to the family of lichens. According to Dillenius and Ray, it was a filiform lichen, found on trees in the East Indies, and which, when moistened, exhaled an odour of musk or of ambergris. It is enrolled by Acharius under the name of Alectoria Arabum, but it must be regarded as merely a conjectural species. In the seventeenth century, some of the filamentous lichens were undoubtedly kept in shops under the name of Usnea; and they formed the basis of a noted perfume called *corps de Cypre gris*, or *pulvis Cyprius*. Their employment for this purpose, however, did not probably depend on any remarkable inherent scent, but on their aptitude for imbibing and retaining odours. Lichen prunastri (Evernia prunastri, Ach.) is, in fact, as well adapted for this purpose, though nowise fragrant; and to this day this species forms the basis of several perfumed powders.

Dyeing.—Various species of lichen have long been used by the common people in the northern countries of Europe for communicating different tints to cloths of home manufacture. These are generally of coarse wool, and the process of dyeing them is proportionally rude. Several species, however, have likewise been employed by artists, and from these the colour has been extracted with the care and skill of the practical chemist.—See article DYEING.

The *orchal*, or *archil*, (Rocella tinctoria) is the most valuable lichen as a dye-stuff. If we may trust to Tournefort, the properties of this species were familiar to the ancients; it was collected in the islands of the Archipelago, and from one of these acquired the name of *Purple of Amorgus*. In modern times, according to Berthollet, it was first prepared as an article of commerce at Florence, the fine violet colour which resulted from mixing it with urine having been accidentally observed by a Florentine merchant, about the year 1300, while visiting the Levant. The lichen, reduced to powder, is put into a vat with urine and quicklime, and frequently stirred, additional portions of these substances being added, till the mixture have acquired the desired tint. Orchal, thus prepared, yields a purple or purplish-red colour, which is not, however, easily fixed. The alcohol in spirit thermometers is usually tinged with orchal, and will afford to the reader an idea of the tint commonly produced. It is sometimes employed, and with great success, for brightening other colours. The lichen grows very abundantly on the sea rocks of the Cape Verd, and also of the Canary Islands, and from both clusters it is exported in considerable quantities. About the year 1750, not less than 100 tons were annually collected in these islands. In the English market, it is at present (1818,) worth about 200*l.* per ton, the price varying, to the extent perhaps of 40*l.* a ton, according to the quality of the *weed*, as the merchants call it. The plant occurs but sparingly, on the sea-rocks of the south of England. In France it is called *orseille*, and is used to a considerable extent, in the southern provinces, for dyeing silks, being collected on the rocky shores of the Mediterranean. By the Dutch it is manufactured into a paste, called by them *Lacmus* or *Litmus*. This is sold in square masses about an inch in length, and half an inch in breadth and thickness, hard and brittle, having the appearance of a violet-coloured earth, with white spots. It may here be remarked, that another species of Roccella, R. fuciformis, is reported to vie in richness of colouring matter with the common orchal, while the plant attains to a much larger size. This species, like the former, occurs sparingly on the sea-rocks of the South of England; but it is said to abound in the East Indies, especially on the shores of Sumatra, and might deserve the notice of some of our enterprizing countrymen.

The names of Orchal and Orseille are bestowed also on Lecanora tartarea, which has, to a considerable extent, been employed as a substitute for the other. This species has long been noted for its property of yielding copiously a red, or brownish red colour, equally beautiful, it is thought, but less durable, than the colour yielded by the true orchal. Its use was early known in West Gothland; and, to this day, it is collected in Sweden and Norway, and brought in whole cargoes to Britain. At Glasgow it is called *cudbear*—a denomination which it has acquired from a corrupt pronunciation of the Christian name of the chemist who first employed it on the great scale (Dr. *Cuthbert* Gordon); at least it is the principal species used in the cudbear manufacture, for Urceolaria calcaria, and some other kinds, are commonly intermixed, being gathered promiscuously by the people employed. The true cudbear lichen might easily be distinguished by its yellow saucers, while U. calcaria might as readily be discriminated by its black tubercles. It is not uncommon on the rocks of this country. In the rocky districts of Westmoreland and Cumberland, it is gathered by the peasantry for dyers, who pay them at the rate of 1*d.* a pound; and it is likewise collected in various parts of Scotland, where it often covers the different kinds of trap and clay-stone rocks. Considerable quantities of the dye-stuff are sold to manufacturers engaged in the woollen and silk trade, generally at the rate of about 10*l.* per cwt.; and the makers of the article, themselves, employ a part of it in dyeing cottons of a Turkey-red colour. The cotton pulicate handkerchiefs of Glasgow are dyed with this preparation; and the fixedness of the colour is well known.

Dillenius first took notice of a species of lichen, which he observed to be in use among the natives of Caernarvonshire for dyeing scarlet, and which they preferred even to orchal. He describes it: "tartareum, tinctorium, candidum, tuberculis atris." From thence it has been considered as the Lichen calcarius of Linnæus, or Urceolaria calcaria, Ach. which has just been mentioned as usually intermixed with cudbear lichen. Dillenius supposed that this is the species mentioned by Martin, in his *History of the Western Islands of Scotland*, under the name of *corkir*, and with which the inhabitants produce a reddish colour. This lichen does occur in these islands, but it is not common, the great body of rocks not being calcareous, or of the kind to which this species is almost peculiar. The cudbear lichen, Lecanora tartarea, is the true *corcur* of the Scottish Highlanders, and which, as mentioned by Lightfoot, they employ for dyeing a claret or pompadour colour. It is usually prepared by pounding the lichen, and mixing it with stale chamber-ley, to which a little salt or kelp is added; this mixture is kept in a state of maceration for several weeks; being then brought to the consistence of coarse paste, it is made up into balls, with a little lime or burnt shells, and is kept ready for use. When used, it is coarsely powdered, and a small portion of alum is generally added. The other lichens employed by the country people as dye-stuffs are prepared much in the same way.

The *perelle* or *Orseille d'Auvergne*, prepared from Lecanora parella, was long a favourite material among the *teinturiers* of France, before the lichen was collected for economical purposes in this country. It is now, according to Withering, gathered in considerable quantities on the rocks in the north of England, and sent to London in casks. From this species the finest *litmus* is prepared; slips of unsized paper stained with which are well known to chemists as delicate tests for ascertaining the presence of minute portions of uncombined acids. It may be noticed, that M. de Cocq, in a memoir in the *Annales de Chimie*, has created some doubt as to the species of lichen from which the perelle or orchal of Auvergne is procured: It is possible that the dye-stuff sold under those names may, in a great measure, be manufactured from the common Roccella; but in the *Flore Française* of Lamarck and Decandolle, the Patellaria (Lecanora) parella is, without hesitation, referred to as the genuine source. Dr. Westring mentions Lichen parellus as the only one which yielded to him a real blue; this it did merely by infusion; but he adds, that the colour is fugitive, nor could he discover any mordant capable of fixing it.

The Parmelia saxatilis is still used in some parts of Scotland for dyeing woollen yarns, and is known to the peasantry by the name of *Stane-raw*. It is also commonly employed in Sweden, and other northern countries, for the same purpose. Dr. Withering mentions, that, in these countries, it gives a purple colour; but, as managed in Scotland, it yields only a dirty orange. Parmelia omphalodes is much used by the Scottish Highlanders, under the name of *crotal*, for dyeing a reddish-brown. According to Rutty, Parmelia caperata is used in the north of Ireland and in the Isle of Man for dyeing wool of an orange colour, and is often called *arcell*. The Sticta pulmonacea, already repeatedly mentioned, is sometimes resorted to by the same class of people for tinging their yarn of a brown colour. In the north and west of Scotland these lichens are sometimes promiscuously called *crottles*: in England, it is believed, they often get the name of *rags*, or *hazel-rags*, and in the south of Scotland *hazel-raw*. Although several species of lichen very different in habit and qualities, are thus used by the common people of this country, so very defective are the means employed, that they procure scarcely more than one colour.—Linnæus mentions that a beautiful red colour may be prepared from Lichen pustulatus (Gyrophora pustulata, Ach.); and Dr. Withering informs us, that it also yields a very deep black paint. A lichen allied to this, and which has already been mentioned as an edible species, Gyrophora cylindrica, is used by the Icelanders for dyeing woollen stuffs of brownish-green colour. In Sweden, especially in Smaland, and also in Norway, Evernia vulpina, (the poisonou property of which has before been noticed,) is used for dyeing woollen-stuffs yellow. The Cetraria Islandica, which has already been spoken of, both as an article of food and as a medicine, is used in Iceland for dyeing brown. The colour resides in the extractive matter, which is separated by slight boiling, or by merely steeping in warm water.—We have the authority of Bartram, the traveller, for stating, that Lichen barbatus (Usnea barbata, Ach.) is collected in quantities from the trees in Pennsylvania, and employed by the people for communicating an orange hue to yarn.

The species which have been mentioned are remarkable for abounding in colouring matter, and for the facility with which they communicate it to woollen, cotton, or silken fabrics. Many other species, however, afford colour, and some minute lichens give the finest tints. The writer of this article, many years ago, made experiments, on a small scale, on some of the lichens which are found on the rocks in the neighbourhood of Edinburgh. Merely by drying and pounding, and then throwing the powder into a phial containing a little liquid ammonia or lime-water, or sometimes a mixture of both, and fitting the phial with a cork, some beautiful colours were procured, not however till after the lapse of several days. Slips of white paper were the only substances stained: the paper ought to be *unsized*, in which state it may be procured from the manufacturer; for India paper, probably merely on account of its being destitute of any glutinous ingredient, received the delicate tints more freely and equally than that of English manufacture. Treated in this way, Lecanora ventosa, which is plentiful on some parts of the rocks of Arthur Seat hills, gave a beautiful violet tint, superior to what was procured, by the same process, from Lecanora parella. Ramalina scopulorum, from sea-rocks at Carolina Park, afforded little or no colour when young plants were used, and a dull orange when old stems or fronds were employed. Parmelia conspersa yielded a very fine gamboge yellow; and Parmelia parietina a yellow scarcely inferior in beauty, but approaching to orange: This last species, as intimated in the trivial name, abounds on old walls, and might easily be scraped off and collected in considerable quantity: Both in it, and in P. conspersa, (Lichen centrifugus, Lin.) the central parts of the thallus often decay, and the plants then appear to grow in circles. Lepraria chlorina, which grows along with P. parietina, and in general appearance resembles it, having a fine lemon-yellow crust, afforded no yellow colour at all, but rather a peach-blossom tint, which was not permanent. Lecidea sanguinaria, from rocks in the King's Park, instead of yielding a scarlet, as was expected from the red colour of the tubercles when cut, gave only a dull lead-grey. Neither the external nor internal colour of the lichen, therefore, afforded any indication of the tint which might result from the powder treated with the ammonia and lime-water. By such simple means, however, it may in general be ascertained whether any particular species of lichen is likely to yield colour at all: and it may here be remarked, that if it yields colour readily and copiously, these are the principal and most desirable qualities; for brown, purple, or orange, though at first they come dull and dirty, may in general be greatly improved, in intensity and brilliancy, by varying the processes, or enlarging the quantities employed; and it not unfrequently happens, that the colour which first shows itself is, after a few days, or in consequence of some slight change of management, replaced by one more agreeable to the eye, and which would prove more valuable in the arts. It may be added, that where the same species of lichen grows both on rocks and on trees, which is not an uncommon occurrence, the specimens taken from the rocks will be found evidently more productive of colour than those picked from the trees. The particular nature of the colouring matter in lichens does not appear to have been yet subjected to accurate examination by chemists.

This part of the subject has been excellently illustrated by the labours of Dr. Westring of Nordköping, physician to the king of Sweden, who has given ample details of judiciously varied experiments made by him upon most species of lichen indigenous to Sweden, and upon a considerably extended scale, with the view of ascertaining their effect in dyeing woollen-stuffs and silks. It may be proper here to detail the general rules laid down by this assiduous experimenter, (translated from the Stockholm Transactions into the *Annales de Chimie* for 1792): these rules may easily be followed by any person inclined to pursue the investigation,—and the subject is by no means exhausted.

The lichens should be gathered after some days of rain, when they can most easily be detached from the rocks. They are to be well washed; then thoroughly dried, and reduced to a powder, the finer the better. Pure river water is to be used, the water of wells generally containing some earthy or saline ingredient, which is apt to alter the hue. Twenty-five parts of water are to be added to one of powdered lichen. When quicklime is employed, it should be quite fresh; and one part of quicklime is enough to ten parts of powdered lichen. To ten pounds of the lichen, half a pound of sal ammoniac (muriate of ammonia) is sufficient. Before plunging the thread or stuffs to be coloured into the dye, they should be dipped in pure cold water, in order that the colouring matter may act more equally: and they should be immersed in the same way when taken out. When lime and sal ammoniac are used together, the vessel containing the mixture should be closely covered for the first two or three days. Sometimes the addition of a little common salt (muriate of soda,) or of saltpetre (nitrate of potass,) will be found to give a greater lustre to the colours. Dr. Westring did not, in general, employ any mordant; indeed, any acidity in the mordant could not fail rather to destroy the gummy part of the lichens, which probably serves to fix their colours. From several species, the Doctor procured colours naturally so permanent that they resisted both acids and alkalies, and were not affected even by exposure for a considerable time to the sun's rays. In some instances, however, he employed different species of lycopodium as mordants, and with considerable success. He praises, in particular, Lycopodium annotinum, a species which is found on some of the Scottish mountains. Some lichens yielded a good colour when macerated in a cold liquid, and the same species in a hot liquid gave a different and inferior hue: but the fact was in other instances reversed.

Dr. Westring made trial of many of the *Lichenes leprosi* of Linnæus, especially species belonging to the genera Lecanora and Urceolaria of Acharius, but including also some species of Porina, Lecidea, and Isidium. The coralline-like species of the last-named genus were found to be extremely rich in colouring matter; and Lichen corallinus of Linnæus (Isidium corallinum, Ach.), and especially L. pseudo-corallinus of Swartz (now appropriately named by Acharius, Isidium Westringii,) deserve the particular attention of those who practise, and who wish to improve, the art of dyeing. I. corallinum is found abundantly on the Swedish mountains, and Westring gives it as his opinion, that it may probably become a lucrative object of commerce. It is not uncommon on the rocks in some parts of Scotland. Worsted thread, kept for about three days in the simple infusion of the lichen, acquired a pistachio-green colour. When a little common salt was added to the infusion, it communicated to the thread a citron-yellow. From the lichen digested in spirit of wine for four-and-twenty hours, a wax yellow was procured; and when the digestion was continued for three days, a deep chestnut-brown resulted. But, what is more interesting, when the lichen was digested in simple water for the space of four days, a dark and very beautiful chestnut-brown was procured, of so fixed a nature, that it was not destroyed when the thread was dipped in dilute aquafortis. A shred of silk steeped in a bath composed of the water in which the lichen had been boiled for half an hour, with the addition of some common salt, acquired a fine and brilliant gold yellow colour. I. Westringii possesses qualities of still a higher character, and seems to be superior in tinging properties to orchal itself; but it is unfortunately a rare species. It may be enough, therefore, to mention, that it yielded a rich orange colour, which was brightened by the addition of muriate of cobalt. Porina pertusa yielded a brown colour; and Lecanora ventosa communicated to wool the same colour, possessed of so much fixity that it resisted the action of alkalies. Lecanora hæmatomma, (Lichen coccineus of Dickson,) a species which occurs plentifully on the well known Stonehenge pillars, afforded only a wax-yellow colour, notwithstanding the bright red of the tubercles. In Dr. Westring's hands, Lecanora tartarea, or the principal cudbear lichen, yielded to wool a rich puce brown; and it was only by the addition of a solution of tin, that he procured a brownish red, which, however, was very beautiful. Of the *imbricated lichens* he examined the qualities of a good many species, chiefly belonging to the genus Parmelia of Acharius. P. saxatilis, already noticed as still employed in some parts of Scotland for dyeing wool, gave with soda a yellow colour; with lime and sal-ammoniac, a nankeen; and with common salt and nitre, an orange. P. physodes, which grows abundantly on trunks of trees, and on stones in woods, in this country, he found to be very rich in colouring matter, affording, by means of the same reagents, tints varying from a citron yellow to chestnut brown. It deserves notice, that P. stygia yielded, in his experiments, a yellowish colour only, and no red or violet, which preceding writers had ascribed to it. Solorina crocea, although of a saffron-yellow aspect, when treated in the usual way with quicklime and sal-ammoniac, gave out a red colour. This species, as already noticed, occurs on the Scottish mountains, but probably nowhere in sufficient quantity to render it an object of importance.

One of the projects of the ingenious Lord Dundonald was, to introduce the employment of the mucilage of lichens for thickening the mordants, and fixing the colours in calico printing. His lordship remarks, that lichens (meaning chiefly the branched tree-lichens, but without determining accurately the particular species) are composed of different substances. There is the outer skin or cuticle; below that, a green resinous matter: the remainder of the plant consists partly of gum, partly of a matter somewhat analogous to animal substances, and a small proportion of fibrous matter, which is not dissolved by boiling, or by the action of alkaline salts. The first process in preparing the mucilage is to detach the outer skin, and the resinous matter. This is done by scalding two or three times with boiling water, allowing the lichen to remain so long in the water as, by absorbing it, to swell; for in swelling the skin cracks and comes off, along with the greater part of the resinous matter. Or the same thing is accomplished by gently boiling the lichen for a quarter of an hour, then washing it in cold water, and spreading it upon a floor of brick or stone for half a day. An additional reason for this last practice is, that the exposure to the air greatly facilitates the subsequent extraction of the gum. The scalded lichen is then put into a cast iron boiler, with water in the proportion of two wine gallons to every pound of lichen, and boiled during four or five hours, adding about half an ounce of potass or of soda for every pound of lichen; or, instead of these salts, half an English pint of liquid ammonia. The boiling is continued until the liquor acquire a considerable degree of gummy consistence. It is then taken out of the boiler, and allowed to drain through a wire cloth. The residuum may be put into a hair cloth bag, and squeezed in a press similar to that used by tallow-chandlers. The first boiling, however, by no means extracts the whole of the gum. The lichen is boiled a second or even a third time, repeating the process above described, and diminishing each time the quantity of water and of alkali added. When three boilings are employed, the gummy extract of the last may with propriety be reserved for the first boiling of a fresh batch of lichen. The extract proceeding from the first and second boilings is mixed together, and evaporated to the consistence necessary for block or press printing. The evaporating vessels are of tin or thin lead, placed over a range of stoves, and moderately heated, which is best done by steam. The mucilage thus procured is more or less coloured; but Lord Dundonald remarked, that, by continuing the digestion longer, with a low degree of heat, and abstaining from the use of any alkali, it might be produced nearly free of colour. It appears, indeed, from the experiments of M. Georgi, professor of chemistry at St. Petersburgh, that several of the lichens which have already been mentioned, (particularly Ramalina farinacea and Parmelia Physodes), form with water a mucilage, which yields, when evaporated, a gum as transparent as gum arabic, and in the proportion of about an eighth of the weight of the lichen. M. Amoreux repeated and extended the experiments of Georgi, and obtained considerable portions of pure gum from many of the broad-leaved lichens, such as Peltidea canina, Ramalina fraxinea, and Parmelia caperata. All the lichens now mentioned are common in this country; and the two species of Ramalina, in particular, might be collected from trees in many woods and orchards, in great plenty and in great purity.

See *Philosophical Transactions* for 1758, (Watson); *Memoirs of the Academy of Sciences of Lyons*, for 1786. (Willemet); Amoreux *Recherches et Experiences sur divers Lichens*; *Memoirs of the Stockholm Academy, from* 1792 *to* 1799; *Crell's Annals for* 1796, 1797 *and* 1799,—and *Annales de Chimie*, vols. xv. and xvii. (Westring); *Journal de Physique*, vol. lxiii. (Proust); *Philosophical Magazine*, vol. x. (Dundonald.) (P. N.)

LICHFIELD, or LITCHFIELD, is an ancient city of England in Staffordshire, and, united with Coventry, is the see of a bishop. It is situated on a small river running into the Trent, almost in the centre of England, in a healthy and agreeable valley, surrounded by hills of moderate height. The town is divided by a large and fine sheet of water into two parts, the city and the Close; and consists of three or four good streets, with several smaller ones. The principal streets are, Bridge street, vulgarly Bird street, Beacon or Bacon street, and St. John street, running off from this last in a southern direction. The high road from Birmingham to Newcastle-under-Lyne passes through the principal street. Many of the houses in Lichfield are elegant and well built; but several of them are constructed in the ancient style.

The principal public building in Lichfield is the cathedral, situated in the Close, and beside the sheet of water already mentioned. It is supposed to have been built about the year 667, during the bishopric of Juraman. It was rebuilt in 700 by bishop Headda, who dedicated it to St. Chad, and removed his bones to Lichfield from Stowe church. Roger de Clinton erected a great part of the present building. Walter de Langton built the portion of it which is called St. Mary's Chapel, as well as the cloisters; and, at an expense of £2000, he raised a shrine to the memory of St. Chad. The cathedral received great injury from the sieges of the town during the civil wars. Bishop Hacket had the honour of repairing the damage which it then sustained; and, in the year 1788, it underwent a complete repair by private subscription, and under the superintendence of Mr. James Wyatt of London.

The extent of the whole cathedral from east to west is 411 feet in length, and 67 feet in breadth from north to south. It is adorned with three elegant steeples, one 258 feet high, in the centre of the building, and the other two 183 feet high, at its west end. The western front was formerly enriched with the finest sculpture, from subjects of scripture history; but several of these were removed, in 1749, by order of the dean and chapter, and the rest have been much injured by the gradual influence of time. On the summit of the roof, between the two spires, is a statue of Charles II. who had contributed timber towards the repair of the church. It was the work of Sir William Wilson, and is supposed to occupy the place of a more ancient one of Adam, or our Saviour. The portico of the cathedral is not excelled by any in Great Britain, and contains the richest and the lightest sculpture. Within the porch are placed the four evangelists, holding the gospels in their hands. On the two sides are Moses and Aaron; and in the centre, between the great doors, is the Virgin Mary with the infant Jesus. These were formerly richly painted and gilt. The south and north entrances to the cathedral are very fine, particularly the north door, which is rich in the most beautiful sculptured moulding. The roof of the cathedral was once covered with lead, but slates were afterwards substituted.

The body of the cathedral is lofty and spacious, supported by pillars, formed by a variety of slender columns with neat foliated capitals. The length of the body from the great west door to the choir is 213 feet, its breadth 153 feet, the breadth of the side aisles 66 feet, and the height of the nave 60 feet. The upper rows of windows are triangular, including three circles in each. Over the great west door is a magnificent circular window, formed at the expense of James Duke of York, in the reign of Charles II. The painted glass was the gift of Dean Addenbrooke, in 1776. There are many interesting monuments in this church. The principal are, one to Launcelot Addison, the father of the great Addison; one to Lady Mary Wortley Montague, representing the goddess of beauty weeping over an urn; one against the wall to Dr. Samuel Johnson, with a bust of him upon the pedestal; one to the celebrated Garrick, erected by his widow; and one to Mrs. Grove, wife of Dr. William Grove of Lichfield.

The choir and St. Mary's chapel were formerly separated by an elegant architectural screen, but during the late alterations the two were thrown into one. St. Mary's chapel is uncommonly beautiful and magnificent. It contains nine windows, three on each side, and three at the end. The slender east windows are filled with painted glass, which Sir Brooke Boothby purchased from the dissolved abbey of Herckenrode, in the bishopric of Liege. Sir Brooke transferred his purchase to the dean and chapter. It consisted of 340 pieces, each about 22 inches square, and amounted to £1100, including expenses of carriage, and of fitting up the window to receive it. The centre window on the same side exhibits the resurrection, executed by Mr. Egginton, from a design of Sir Joshua Reynolds. The organ, which has the stone screen formerly mentioned for its western enclosure, has twenty-five different stops, and is esteemed a very fine instrument. Both sides of the choir are adorned with twenty-five stalls.

The library, founded by Dean Heywood, contains several valuable books and MSS. One of these MSS. is an ancient copy of the Valor of Pope Nicholas in the time of Edward I.; another is the *Textus St. Cedde*, or the Gospels of St. Chad, written in Saxon characters, and supposed to be about 1000 years old. There is here also a Koran, which was taken from the Turks at the siege of Buda. To the north of St. Mary's chapel there is a smaller chapel, in which the remains of two of the Mercian kings were interred.

The chapter, besides the bishop, consists of a dean, precentor, chancellor, treasurer, 4 archdeacons, 27 prebendaries, 5 priest vicars, 7 lay clerks, 8 choristers, and other subordinate officers.

The bishop's palace stands at the north-east corner of the Close. It is a spacious stone edifice, bearing the date 1687, and the arms of the bishopric. As the bishops now reside at Eccleshall castle, this palace is generally occupied by tenants, and was long the residence of the family of the Sewards. The deanery house stands to the west of the palace. The houses of the prebends are situated in different parts of the Close. The vicarage consists of two small quadrangles of low built houses. A new house, belonging to the registrar of the diocese, was built in 1796, on the site of the ancient prebendal house in which Bishop Hacket lived and died. There is attached to this house a large hall, containing an extensive and valuable museum, established by Mr. Wright, a surgeon in Lichfield. The elegant building, faced with stone, which stands at the entrance of the Close, was built at the expense of Andrew Newton, Esq. for the reception of twenty aged and necessitous widows, or unmarried daughters of clergymen, and has been since liberally endowed for their support.

The city of Lichfield is divided into three parishes, St. Mary's, St. Chad's, and St. Michael's. St. Mary's is in the centre of the town; and the church, supposed to have been originally founded in 855, stands on the south side of the market-place. The old building was taken down in 1717, and the present one substituted in its place. In its external appearance, it is tolerably neat, and is fitted up with oaken pews. The altar-place is handsome, and on the north side of it is the burial place of the Dyott family.

The market house is a light brick building near the church. It consists of eight arches, surmounted by carved rails or bannisters, on the top of which were statues of eight of the apostles.

The guildhall in Bore street is a neat stone edifice, adorned with the city arms, &c. The front hall is spacious, and underneath is a gaol. The theatre, situated in the same street, is a small building, with a stucco front, erected in 1790. At the south-west corner of the street is an English school, founded and endowed by Thomas Minors, Esq. in 1670, for the purpose of "teaching 30 boys of the city to read the Psalter and Bible in English."

In St. John's street stands the free grammar school, founded by King Edward VI. At this school were educated, Addison, Wollaston, Ashmole, Garrick, and Samuel Johnson. The hospital, originally a monastery, stands opposite the school. It is in a flourishing state, and is remarkable for the number and curious form of the chimnies, which are placed in its front. The chapel is built of stone.

The parish of St. Chad lies on the north-east of Lichfield, and embraces a considerable portion of the city and its suburbs. The church, called Stowe church, is very ancient; and the interior of it, which is very neat, has lately undergone a complete repair. In a garden on the west side of the church stands St. Chad's well, which is supposed to possess medicinal qualities. Dr. Milley's hospital for 15 poor women stands in this parish, in Bacon street.

The parish of St. Michael's is on the eastern side of the city, and comprehends a small part of the city. The church is situated on a mount called Greenhill, and is remarkable for its cemetry, which contains no less than seven acres of ground. The church is an old building, with a lofty spire, and is adorned with many monuments, both ancient and modern.

The city of Lichfield is a county by itself, and possesses very extensive and peculiar privileges. The county is about 12 miles in circuit, and is governed by two bailiffs, elected annually out of 24 burgesses, a recorder, sheriff, steward, and inferior officers. It sends two members to parliament, and the number of voters is about 624.

Lichfield is chiefly occupied by genteel families, and persons of small independent fortunes. Its chief manufactures are those of sail-cloth and horse-sheetings; and its principal trade consists in the sale of its ale, for which it has long been famed. The city it situated at the distance of about half a mile from the Wyrley and Essington extension canal. Lichfield has three fairs; one on Ash Wednesday for cattle, sheep, bacon, cheese, and iron; another on May 12th, for sheep and cattle; and another on the first Tuesday of November, for geese and cheese.

It appears by the population return for 1811, that there were 1010 houses, and 5022 inhabitants.

See Harwood's *History and Antiquities of Lichfield*, 1806; Jacksons's *History of the City and Cathedral of Lichfield*, 1805; Shaw's *History and Antiquities of Staffordshire*, vol. i. 1798—1801; and *The Beauties of England and Wales*, vol. xiii. p. 786—819.

LIEGE, the *Leodium* of the ancients, in German *Luttich*, and in Dutch *Luyck*, is a city of the Netherlands, situated on the river Meuse, in a pleasant valley, surrounded by hills, and containing finely watered meadows. This valley is watered by the rivers Loose, Ouste, and Amblese, which throw themselves into the Meuse as it enters the city. Liege has ten great Fauxbourgs and two small ones, and contains 154 streets, 16 gates, 17 bridges, and two quays planted with rows of trees.

The town was formerly divided into the old or high town, and into the new or low town. The last of these divisions comprehends two parts, viz. the isle, and the quarter of the Meuse. The high town is built on the declivity of a hill, and stretches, in a southern direction, to the arm of the Meuse, which separates it from the old or low town called the Isle; and towards the east it touches the great Meuse, which separates it from the quarter beyond the Meuse. The quarter called the Isle is formed by two arms of the Meuse, which rejoin at the lower end of this quarter. The quarter beyond the Meuse, which is nearly a peninsula, is situated, as well as the fauxbourg of Amercœur, between the Meuse and Mount Coruller. There is a communication between the different parts of the town by bridges. The town is well fortified; but the citadel, which was upon the mountain St. Walbourg, has been rased. At the foot of this mountain stood the episcopal palace, which was a very large building. The court of the palace was encircled with a peristyle formed by demi-gothic columns. The Hotel de Ville, which looks into the principal square, is a large, but not a handsome building. It contains a public library. The town is in general ill built, and is filled with a multitude of small streets and lanes, which have not that cleanness and neatness which mark the other towns in Holland.

Before the French revolution, Liege contained, besides its cathedral, seven collegiate churches, 30 parish churches, five abbeys for men, five for women, and 36 convents for both sexes; but it has since suffered greatly, both from the miseries of war, and from the barbarism of the revolutionists.

The cathedral church of St. Lambert is a very large building, but the Gothic style in which it is built is very bad. It was founded in 712 by St. Hubert. The fountains of Liege are very fine; and that which rises near the centre of the great square deserves particular attention.

The trade and manufactures of Liege were at one period very considerable and important. The principal natural productions of the surrounding territory are, mines of coal and alum, tobacco and iron. Great quantities of the alum, which is of an excellent quality, are sent to France. The tobacco is prepared in all its various forms; but the greatest part of it is received from Germany in leaves. Liege is celebrated for its manufactures of iron, which are not surpassed by those in France, and which still preserve their former reputation. Clock-work is made very extensively; but the manufacture of hats has employed from 12,000 to 14,000 workmen. Great quantities of them are sent to Holland, both for its own consumption, and for the East and West India trade. They are also exported in great quantities to France, for the Levant and the coast of Africa. The cloths of Liege are of a very superior quality. The tanneries are in great reputation, and peculiar methods of preparing the leather are said to be practised in them. Great numbers of cannon, stores, &c. are furnished by the iron founderies. The iron is excellent for smelting, and takes a good polish. The other manufactures are those of writing and printing paper, fine china, and black lace, which is preferred by many merchants even to that of Brussels and Mechlin. Population 50,000. East Long. 5° 31′ 42″. North Lat. 50° 39′ 22″. See Rorsdanz's *European Commerce*.

LIEGNITZ, or Lignitz, *Lignicium* in Latin, is one of the best and most ancient towns of Silesia. It is the capital of a principality of the same name, and is situated upon the Katzbach. The palace within the town is surrounded with a moat and high wall. There is here a superb stone edifice, in which the states of the province hold their meetings. The Catholics possess the collegiate church of St. John, which was taken from the Lutherans in 1696; the church and the convent of the Benedictines; the church of St. John Nepomucenus, and the church and the convent of the Franciscans, and its gardens. The Lutherans have two parish churches. The church of St. Peter, and its library; and the pictures of the church of the Holy Cross; the Hotel de Ville; the Magazine of Cloths; and the manufactory of vegetable silk of M. Schnieber, are worthy of being visited. There is also here a college, an hospital, a royal and municipal school of the Confession of Augsburg; and a large academy, founded by the emperor Joseph, erected for the instruction of young men of both religions in military exercises. Liegnitz has many fine promenades. There is a fine view from the height of Goldberg; and at Walstadt, a village two leagues from Liegnitz, there is a convent of the order of St. Benedict, which possesses very fine pictures. This convent is built on the spot where a bloody battle was fought against the Tartars in 1241, when the Duke of Liegnitz perished. The kitchen gardens of Liegnitz are very famous, and from them are exported annually vegetables to the amount of 100,000 rix dollars. There is a well frequented bath at Grunstadt, or Warmbrunnen. Liegnitz carries on a considerable trade in cloth and madder. Population 7000.

LIEOU-KIEOU. See Loo-Choo.

LIFE. See Physiology.

LIFE-Annuities. See Annuities.

LIGHT. See the articles Aberration, Achromatic Telescopes, Botany, Burning Instruments, Chemistry, Heat, Optics, Photometry, Polarisation, &c.

LIGHTHOUSE.

By the term *lighthouse* is understood, an establishment set apart for exhibiting a light as a *landmark* for the use of the mariner. The *fire towers*, or sacred beacons of early ages, not only exhibited such lights, but were the residence of priests, and became seminaries for youth.

Ancient Lighthouses.

At this day, it is difficult to trace the connection between the religious rites of a people, and an establishment apparently so purely nautical; for neither the situation of such buildings, nor their necessary dimensions, would seem to imply such a use. We have, however, the most ample authority from early history for believing that the lighthouses, or sacred towers of antiquity, were dedicated to the gods, and that sacrifices were regularly offered up in them, to appease the raging storm, and implore the safety of the navigator, that he might arrive at his destined shore. We are also informed that these towers were sometimes set apart as *nautical colleges*, where astronomy, and whatever related to the art of navigation, was publicly taught; and that they became the depositaries of the most correct observations regarding the heavenly bodies, and also of the charts of the coasts. These were originally delineated or traced upon the walls of the apartments; but, in after times, rude maps were transferred, and extended upon the papyrus of the Nile.

In all ages, it seems to have been natural for mankind to ascribe every thing that is imperfectly known to a sacred origin, and these towers were accordingly considered as the temples of the gods, and, like the vestal fire, the lights were said never to be extinguished. Here the mariner and the traveller performed rites, and practised the arts of divination, to inquire into the success of their voyage, or make votive offerings for past deliverances.

The Ammonians, whose commerce is said to have extended from the Pillars of Gades to the Ganges, and who were certainly the greatest commercial people of early times, are understood to have been the founders of these maritime temples, which they styled *tar* or *tor*, signifying both a hill and a tower, words which, when compounded, may be rendered *tor-is fir*, or fire towers.

Of the construction of these buildings we have but very imperfect accounts. They appear to have consisted of a tower of masonry, sometimes of very large dimensions, of a circular form, but more generally square, perhaps from being considered more suitable for the purposes of astronomical observation. These buildings consisted of various apartments, according to the extent of the establishment, and were finished upon the top with a battlement. Within, a kind of altar piece was raised, which was covered with a plate or chauffing-dish of brass: and upon this brazen hearth a chauffer was placed. These chauffers were of curious workmanship, supported upon dolphins, and the grating decorated with foliage and various emblematical devices.

Before the discovery of the magnet, or its application at sea, these towers were much more numerous; for every promontory is said to have had its lighthouse or temple. In those days the mariner was under the necessity of observing, with the most servile attention, all the sinuosities of the shore, and these lighthouses were at hand to forewarn him of his danger; here also he rested his weary limbs, and received fresh instructions for his voyage.

In the fortification of early ages, the fire tower became a prominent part of the building. In Italy, especially, where the sea shore formed the point of attack for the pirate, and the chief boundary against intruding nations to seaward, watch towers were erected, from which chauffers or grates were suspended by night in a sloping direction; and previous to the invention of the trumpet, or the application of more distant signals, the watchmen of these towers were provided with large sea-conchs, which they sounded from the battlements by day, to give warning to the mariner of his situation, or to alarm the country in cases of an enemy. Hence also the custom of *torrone*, or alarm towers, at a distance from the sea coast, to give warning for the removal of cattle and provender from an approaching foe.

Many of the most intricate and fanciful passages in ancient history have been explained, by the curious researches of Mr. Bryant regarding these sacred towers or lighthouses, in his *Analysis of Ancient History*. It is believed that Pompey's Pillar, near Alexandria, so famed in ancient history, was originally constructed as a sacred beacon, and is the same with Omphi, P. Omphi, and Pompi. The same may be said of the Pillars of Gades, sacred to Hercules, and others upon the shores of the Mediterranean, as those at the noted passage Fretum Gaditanum, and many others, sacred to the sun, *Col or*, and to Apollo of Greece, who was the tutelar god of the coast. These, when erected upon elevated situations, were called *tith*; and the long-lived *Tith-onus* was literally an Ammonian lighthouse. The fire tower called *Thith is*, was sacred to Thetis the goddess of the sea. The arrows of Apollo, thrown with dreadful slaughter at the Cyclops, were figurative of the rays of the sun extinguishing the fires, or Cyclopian lighthouses, situated on the eastern coast of Sicily, or the one-eyed Cyclops, so dreadful in fabulous history.

The temple of Chiron, the tower of the sun, famous for the instruction of youth, was one of these sacred beacons inhabited by priests. Here Achilles and Jason received instructions in astronomy and navigation. Another Chironian tower, serving both as a temple and a lighthouse, was dedicated to Castor, the tutelar god of mariners. Charon, the celebrated ferryman of the Styx, is the same with Chiron, whose temple stood on the western side of the Nile, opposite to Memphis, and adjoining the catacombs on the Achironian plain, where persons of distinction were interred; and at this tower an offering was made to Charon when the body was landed.

But these sacred fire towers or beacons, originally instituted for the direction and protection of the mariner, for administering offices of kindness and hospitality, and applicable also to the joint purposes of science and the worship of the gods, became in time scenes of the most horrid outrages and cruelty, from the dissolute manners and barbarity of the priests and priestesses who were stationed at them. Accordingly we find an extraordinary perversion of these once sacred places. The temple of the god Neaas for example, the same with Noas or Noah, was the dreaded Minos of Crete, mentioned by Diodorus as the first law-giver, and a great promoter of civilization, to whom the sacred beacon *Men-tor*, the tower of Men or Menes, was dedicated. Scylla, on the cost of Regium, was another of these Ammonian towers, rendered famous as the dread of mariners. In the Minotaurus or Menis of Crete, some of the principal youths of Athens were sacrificed in the same manner as the Carthaginians sent their children to be massacred at Tyre. It is also believed that human flesh was eaten in these places; and we learn from Virgil, that Ulysses entering Regium, had six of his companions seized at Scylla, and the like number in the cavern of the Cyclops. The common mode of sacrificing strangers at these shrines, and of seizing upon their property, was to invite them to wrestle in the area or court of the building, with an athletic priest, trained to the exercise, and skilled in these works of death. Such is the contrast between the sacred and useful purposes for which these fire towers were instituted, that their cruel inhabitants, the priests and priestesses of fire, were at length enrolled with demons; and their temples or towers were dispersed upon the sea-coast of Sicily, Italy, Greece, and Lybia.

The whole of these ancient establishments of fire towers or lighthouses, which were so common on the shores of the Mediterranean, the Archipelago, the Bosphorus, and Red Seas, have long since disappeared.

Before, however, noticing lighthouses of a more modern date, we must not fail to communicate the little we know concerning the Pharos of Alexandria, which is accounted one of the seven wonders of the world, and seems, from the extent and magnitude of the structure, to have been intended by its founder, Ptolemy Philadelphus, to perpetuate the glory of his name. This edifice is said to have been erected about 300 years before the Christian era. It was the work of *Sostratus*, and according to Pliny, bore an inscription to this purport: "Sostratus the Cnidian, the son of Dexiphanes, to the gods preservers for the benefit of those who use the sea." It is, however, recorded by Lucian, that this inscription was artfully covered over with plaster, on which the name of Ptolemy was inscribed, and when this perishable material crumbled away, the name only of Sostratus remained; a story which is altogether improbable, and which, as it rests solely on the authority of Lucian the satirist, has been generally rejected as unworthy of the character of so eminent an artist.

The dimensions, either of the area or height of this celebrated building, are by no means ascertained; some have, indeed, ascribed to it a height of 300 cubits, or 100 statues of man, which would make it of the gigantic height of about 550 feet. It is described as a square building of Turburtine stone, or granite of a whitish colour, and of exquisite workmanship. On the top a fire was kept constantly burning, which, according to Josephus, was seen at the distance of 300 stadia, or about 42 British miles; but this is too moderate a calculation, for those who delight in the marvellous have extended this distance to no less than 100 miles; while others assert that shipping could be seen, by means of a speculum, from the top of this lighthouse, even from Constantinople, a distance of about 700 miles!

This immense work is said to have cost 800 talents, but as authors are not agreed about the value of a talent, this will admit of a range extending from one to three hundred thousand pounds Sterling. With these doubtful and unsatisfactory remarks regarding this eminent building, we may take leave of the ancient lighthouses. In vain do we look for improvement at this day on these classic shores; for though we have still a Pharos of Alexandria, and a Pharos de Messina, upon that coast, yet they come far short of modern improvement in this department of the arts, at least in regard to the appearance and effect of the lights. Even in the more modern commercial kingdoms of Spain and Portugal, this remark is equally applicable; while in point of brilliancy, substantial utility, and boldness of design, the lighthouses of the present day were not perhaps exceeded in any age of the world. An instance of this occurs, in the celebrated lighthouse of Corunna, or famous tower of Hercules, noticed in Humboldt's travels as merely a coal-fire, exhibiting so weak and languid a light, that ships can hardly perceive it until they are in danger of striking against the shore.

Lighthouses on the European Continent.

We have already noticed the state of the Mediterranean seas with regard to lighthouses in early periods, and concluded, that these structures must have been very numerous. Prior indeed to the discovery of the mariner's compass, the only direction which the sailor had, was obtained from servilely following the shore, and from an acquaintance with the position of the heavenly bodies. It is the more probable that lighthouses in those days were extremely numerous, even long after they had ceased to be used as religious establishments. Upon the discovery of the magnet, however, it is likely that lighthouses would be much reduced in number, and be confined to the most prominent parts of the coast, as is the practice of the present day.

The lighthouses connected with the navigation of the Mediterranean sea, are generally erected upon some of the extensive moles, or near the entrance of harbours. Although, from the little attention hitherto paid to this, subject, our knowledge of them is rather circumscribed, we may notice, that in the higher parts of that sea, besides the famous Pharos of Alexandria, there is a lighthouse on each side of the Dardanelles, or straits of Constantinople; one in the Archipelago, on the island of Milo; two on the Gulf of Salonica; and one near Lagos in Romania. In the lower parts of this sea, we have a lighthouse on the island of Malta; the Pharos of Messina; Leghorn; Civita Vecchia; Genoa, of which we have given an elevation in Plate CCCXLVIII. Upon the same side of the Mediterranean, we have the revolving light of Malaga, Cape Tarifa, &c. &c. &c.

On the coasts of Spain and Portugal, without the Mediterranean sea, the most remarkable lighthouses are those of Lisbon and Corunna, or famous tower of Hercules, an elevation of which is given in Plate CCCXLVIII. This celebrated building measures 92 feet in height, and its walls are 4½ feet in thickness. It is said to bear evident marks of having been built by the Romans; and by an inscription on the building, it appears to have been the work of Caius Servius Lussus, of the city of Aqua Fluvia.

The most remarkable lighthouse on the coast of France is the tower of Corduan, situate upon a large rock, or low island, about three miles from land, at the entrance of the river Garonne, leading to the Languedoc canal; and from its position relatively to the extensive trade of Bourdeaux and the Bay of Biscay, this lighthouse must be of the most essential consequence to the mariner, upon that dangerous and much frequented coast.

This edifice, like the Pharos of Alexandria, seems to have been intended to commemorate an era in the history of France, from the eminent utility of the building, and the magnificence of its structure. It was founded in the reign of Henry II. the Great, king of France, in the year 1584, and was carried on during the reigns of three successive monarchs, having been completed in 1610, in the time of Henry IV.; this building required a period of 26 years for its accomplishment, and was long and justly regarded as one of the chief wonders of modern Europe, in the same manner as the Pharos of Alexandria was in ancient times.

We have given a section of it in Plate CCCXLVII.; and, according to Belidor's description, in his *Architecture Hydraulique*, it measures about 145 feet in diameter at the base, and 145 feet in height. Its style of architecture seems to be a mixture of Grecian, Roman, and Gothic, and it is so splendid, that we should in vain attempt to give any minute description of its parts, without being able to refer to drawings in detail, which would be foreign to the purpose of this work. We shall therefore briefly notice, that the immense platform of 135 feet in diameter, already mentioned, is built of solid masonry, which is surrounded by a parapet or wall of circumvallation. In the centre of this platform, (as will be observed from the *section* in the plate, which we judge to be more descriptive than an *elevation*,) it will be observed that the great tower is carried up. The light-keepers' houses and store-places are not, however, included in the main tower, but form a detached range of buildings on the great platform. The apartments in the lighthouse being laid out upon a great scale, were probably considered too elegant for the habitation of the light-keepers, who ascend from their apartments by a private staircase connected with the building. At the entrance door of the great tower, the busts of Henry II. and Henry IV. are placed in niches; over these are the arms of France, and an emblematical figure of St. Mary, to whom the building is dedicated; another female figure is also placed here, holding a branch of palm in one hand, and a crown in the other.

Immediately over the cellar or store for fuel, formed in the solid masonry of the platform, is the great hall, measuring 22 feet square, with an arched roof 20 feet in height. On this floor are also two wardrobes, and other conveniences. Over the hall is the *King's room*, containing a grand saloon 21 feet square, with an elliptical roof 20 feet in height. This floor has also a vestibule, two wardrobes, and other conveniences.

The next apartment, or third floor in height, is the chapel; for, besides persons to attend the light, there is a priest, who occasionally performs mass in the lighthouse. The elegant apartment devoted for this purpose measures 21 feet in diameter; and from the floor to the centre of the dome-roof, the chapel measures no less than 40 feet in height. This apartment is highly wrought in mosaic workmanship, and is lighted by eight lantern windows. In the crown of this dome there is a circular void, surrounded by a ballustrade, through which is seen the ornamental roof of the room immediately above, which gives the whole a beautiful effect in perspective.

The apartment over the chapel is reduced in size, and measures only 14 feet in diameter, and 27 feet in height: it is used as a watch-room by the light-keepers, and was probably intended as a place to which they and other attendants would be admitted to prayers or mass, upon occasions when the house was honoured by a royal visit. Over this there is an apartment immediately under the light room, for holding a stock of fuel sufficient for one night's consumption, which is constructed in such a manner as to be capable of being converted into a room for the exhibition of a light, in case of accident or repairs being required to any extent in the main light-room, which is situated immediately over this, with a balcony and a circular stone parapet round it. From the floor to the top of the cupola of the original lantern, or light-room, it measured 17 feet in height; and being unglazed, the smoke was carried out on either side in the direction of the wind. The roof was also furnished with a kind of chimney, in the shape of a spire, which terminated the building with a ball. The whole light-room was of stone, and measured 31 feet in height from the light-room floor to the ball on the top of the spire-funnel for the smoke.

The light exhibited in the lantern of the famous tower de Corduan, was at first derived from the combustion of oak-wood, exposed in a kind of chauffer raised about six feet above the floor. From the smallness of the light-room, the fire had so much affected the stone mullions which supported the cupola roof, that, in 1717, it was found necessary to remove the light to the apartment below, till the light-room and upper works were renewed. But, from some defect in the position or nature of the new light, it could only be seen at the distance of about six miles at sea, which produced frequent complaints. The remedying of this defect was at length given in charge to M. Berti, engineer in chief at Bourdeaux, under whose direction the light-room underwent great alterations, when iron was substituted for stone in the construction of the lantern; and this was now made much more open, so that the light passed with less obstruction. In this improved state it was again exhibited in 1727, to the great satisfaction of mariners, after a lapse of no less than ten years.

Instead of timber the use of pit-coal was now introduced as fuel, and the interior of the cupola or roof of the light-room was converted into a kind of inverted conical reflector, the apex of which projected downwards, and its base extended nearly to the full size of the roof of the light-room; as will be seen from our plate. Still, however, the fire being exposed to the weather in an open chauffer, the light, after all, was but little to be depended upon, at more than three or four leagues from the shore. This magnificent structure, which has now stood the test of ages, and having, in some of the late reigns of the kings of France, been fitted up with lamps and reflectors, the light is seen at a proper distance: and affords, upon the whole, an example of the attention which the French court paid to its maritime affairs, even at a very early period.

Besides the celebrated tower de Corduan, we have the following lighthouses on the coast of France, viz.

Oleron—A double light.
Rochelle—A single light on the island of Rée.
Brest—A single light at St. Mathew's Point.
Ushant—One light.
Cape Frehel—One light.
Granville—One light.
Caskets—Three revolving lights belonging to the English government.
Cape Barfleur—One light.
Cape de La Héve—Two lighthouses.

Cape Lailly—One light
Dieppe—One light.
Cayeux—One light.
Calais—One revolving light.
Ostend—One light.

Proceeding along the shores in an eastern direction, we next come to the kingdom of the Netherlands, the lighthouses on which may be enumerated as follows, viz.

Sconce Point—One light, blinded in such a manner that vessels plying to windward must tack on each side the channel whenever the light appears.
Scowen—Two lights.
South Beverland—One light.
Goree Church—One light.
Schevelingen—One light.
Wyk op Zee—One light.
Katwyk—One light.
Nordwyk-op-Zee—One light.
Stanfort—One light.
Egmont-op-Zee—Two lights.
Helder, mouth of the Texel—One light.
Urck Island, in the Zuyder Zee—One light.
Shokland Island, in the Zuyder Zee—One light.
Kampen, in the Zuyder Zee—One light.
Marchen Island, in the Zuyder Zee—One light.
Borkum, mouth of the Ems—One light.
Wrangeroog Church—One light.
Heligoland,—One light from oil, with reflectors, now belonging to England.
Island New Werk, mouth of the Elbe—One light.

On these low sandy shores, lighthouses are pretty numerous; it is, however, much to be regretted, that they are by no means in an effective condition. The light in some of these is simply from lamps with oil without the aid of reflectors, and others are still *coal fires*, exposed in open chauffers to all the vicissitudes of the weather. From the unhappy state of affairs for the last 25 years, these kingdoms, although depending wholly upon commerce, are, in regard to lighthouses, but in a state of infancy. This important subject has, however, by no means escaped the attention of the government of the Netherlands, which has of late years been turned to the erection of better lighthouses on this dangerous coast; and several of them have already been improved by the introduction of glazed lighthouses with reflecting apparatus. From the lowness of these shores, lighthouses are, in some instances, placed on the tops of neighbouring churches, as a matter of economy, though at a considerable distance from the coast.

Upon the shores of Denmark, Sweden, and Russia, in the Baltic Sea, there are a considerable number of lighthouses erected, owing to the broken state of the coast, which is detached by numerous projecting points, while the sea is interspersed with small islands. The chief lighthouses in the Baltic may be enumerated as follows, viz.

Naze—Two lights.
Scaw—One light.
Great Farder Island—One light.
Marstrand Castle—One revolving light.
Nidingen Island—Two lights.
Anholt—Two lights.
Koll Point—One light.
Nakke Hoved—Two lights.
Helsterbo Point—One light.
Gadesby Point—One light.
Oeland—One light.
Lands' Ort—One light.
Sandamn Channel—Two lights.
Point of Helton—One light.
Dantzic—Two lights.
Pillau—One light.
Surep Head—One light.
Pakerort—One light.
Odensholm—One light.
Dagger Ort—One light.
Svortvarort—One light.
Domesnes—Two lights.
Runo Island—One light.
Bruster Ort—Two lights.
Memel—One light.
Bornholm—One light.
Eartholm—One light.

Three additional lighthouses have lately been erected on these shores, viz. at Fort Carrut, at the mouth of the Duna, where there are two stationary leading lights, and at Osterarn island, where there is a stationary light from pit-coal.

In those countries where the chief fuel is timber, it was common in early times to maintain a light from burning billets of wood, but this has been changed for the combustion of pit-coal imported at a great expence. It is indeed but of a recent date that any of the lighthouses in the Baltic consisted of glazed light-rooms for the combustion of oil. These lights of course afforded but an indifferent direction for the mariner. The cause of this state of things may be sought for perhaps in the difficulty of maintaining the combustion of oil in a cold climate, and also from the houses being only lighted during the summer months, when the Baltic is not frozen over. Of late years the lighthouses of that sea have been placed upon a more regular system, and are now lighted chiefly with oil, aided by reflectors.

From the Naze of Norway or Scaw, where a light is exhibited at the northern entrance of the Baltic to the North Cape and Archangel in the White Sea, the coast is entirely destitute of lighthouses; but it is to be hoped, that this state of things will not be allowed to continue long.

Asia, Africa, &c.

If we continue our course beyond the European coast to the more remote quarters of the globe, we shall find the shores in general in a very naked state with regard to this most necessary appendage to the navigation of the seas. We have occasion to know something of the consideration which is given to the marine surveys of the Indian seas by the indefatigable labours of Mr. Horsburgh, hydrographer to the East India Company. But as yet, in so far as we know, nothing has been done in the lighthouse department in these seas, if perhaps we except the erection of a lighthouse at Old Woman's Island, at the entrance of Bombay harbour; and another on the island of Jauper, at the entrance of the Hoogly.

Hence we too often observe, that even with the aid of the best charts, after the mariner has braved all the dangers of the high seas, it is his unfortunate lot to be stranded or lost on approaching the shore. It must be confessed, however, that it is difficult to conceive how any general plan could be adopted in the lighthouse department upon so vast an extent of coast. In the track which ships take in sailing from Great Britain to the East Indies, in order to get into the trade-winds, it is not very obvious that lighthouses would be of the important use which they would prove to be in the narrow seas and islands of the East, unless on those points of land which ships generally make, such as the Madeira islands, St. Helena, the Cape of Good Hope, &c.

On many of the headlands of the eastern straits and shores, lighthouses seem to be much wanted; and it is rather surprising, that amidst the sums which have been expended in the acquirement and defence of so vast a territory, that so little should have hitherto been done for the protection of the mariner in this respect. By these observations it is not meant that there is any neglect on the part of that great company to the safety of so deserving a class of their servants as the mariner; it only follows as a matter to be regretted, that in this department there has been no general system adopted for the erection of lighthouses on the shores of our East India possessions. Under such circumstances, the lighthouses would fall to be supported and maintained by a toll or duty, leviable from the shipping of all the nations frequenting those seas; and there are, no doubt, many situations where such improvements would give much additional security and facility to the business of the mariner.

In the Chinese and Japanese seas, great hazard is encountered from a total want of lighthouses. But as every thing connected with the government and intercourse with these countries is shrouded in darkness, we look here with as little prospect, in regard to the establishment of lighthouses, as we are likely to experience in forming those friendly and commercial connections which so closely unite the prosperity and advancement of mankind.

Australasia, or New Holland, being a country so entirely new to us, we can hardly expect, in the course of things, that lighthouses for the direction of the mariner will be much in demand, nor could they be supported and maintained for a very great length of time. Commerce must be in a flourishing state; and a country must not only have intercourse with many occasional or foreign ships, before it can be supposed to advance in such improvements. It must also have an internal and coasting trade, which is not to be looked for here for a very long time; but we have no doubt that at a comparatively early period, at least in the British settlements, they will follow the example of the mother country, by the erection of lighthouses.

AMERICA AND THE WEST INDIES.

Upon the immense extent of coast of South America, excepting at some particular harbours where lights are erected for the immediate direction of shipping, this country is wholly unprovided with lighthouses; a state, however, in which it is not likely long to remain, if we may judge from the exertions of the Portuguese government, who have lately ordered a reflecting apparatus from England, for a lighthouse to be erected at the entrance of Monte Video.

It is, however, rather surprising that a coast so chequered with islands, and a navigation so hampered with sunken rocks, as that of the West Indies, should be allowed to remain so ill provided with lighthouses, especially from its communication with Great Britain and other European states. We might particularise several promontories and points of land, both in the Windward and Leeward Islands, and principal tracks and passages among them, where lighthouses would be of great importance, if the different nations could agree about defraying the expence of their erection and maintenance.

On the coast of the United states, and the other settlements upon the great country of North America, the want of lighthouses seems to have been early felt; and the convenience and advantage of such establishments would no doubt be duly appreciated, from the experience of the benefits resulting from them in the mother country. Accordingly, we believe that at an early period lighthouses were erected at the entrance of the several rivers, and upon the chief head-lands along the shores of the United States.

These lighthouses, at their first erection, and in the infant state of the country, were of a very rude and imperfect construction. They were originally erected of timber; but it was nevertheless found practicable, though certainly at a great risk, to maintain a light in some of them with billets of wood. These *temporary lights* were not, however, exposed in open chauffers to the weather, as was the case with fires from pit-coal, but were placed in glass casements. The transition from the combustion of timber to that of oil in lamps was, therefore, extremely simple and obvious, and seems to have been early accomplished. At this day, the lighthouses in America, though still in a rude state, are nevertheless fitted up with lamps and reflectors, as that of Sandy Hook, at the entrance to New-York. But as the reflectors are said to be made of tin, there must be a great want of lustre or effect from a reflecting surface so soft and malleable, independently of their great liability to tarnish.

UNITED KINGDOM OF GREAT BRITAIN.

After travelling over such an immense extent of thinly peopled, and comparatively unfrequented coasts, the mind turns with pleasure to the busy shores of Great Britain and Ireland; where comfort and comparative wealth may be seen at every step, whether we examine the public establishments, the trading capital, or the protection which extends itself to the property and persons of the inhabitants, both in the official and in the private walks of life. But we would neither appear fastidious or selfish by drawing comparisons; and shall therefore proceed with our subject; remarking only the relation which seems often to subsist between the private acts of benevolence, and the public establishments of a country: for while we observe an unexampled attention to the education of youth in all ranks of society in Great Britain, and a regard to the comfort and happiness of those in distress throughout the community, the mind is naturally led to similar exertions for the safety of the mariner; even independently of the collateral security of property exposed upon the shelving shores of the coast to all the perils of the ocean. Hence we find that the establishment of lighthouses in Great Britain has generally kept pace with the capital of its merchants, which indeed must always be the precursor of such improvements.

The lighthouses of the United Kingdom of Great Britain form three distinct departments: one for England, under the management of the Trinity House of

London; one for Scotland, under the Commissioners of the Northern Lighthouses, who hold their meetings in Edinburgh; and the third establishment, for Ireland, is placed under the direction of the Board for the improvement of the port of Dublin.

England.

It would appear that, prior to the establishment of public lights on the coast of England, the mariner was left to grope his way along the shores as he best could; and though there might have existed some harbour lights or others of a local nature, yet the first *sea light*, for which a toll or duty was leviable upon all vessels entering an English port, and deriving benefit from it, was the light erected at Dungeness, a point of land upon the coast of Kent, for the direction of what was then termed the *south fleet*. This light is still of the same great importance to the navigation of the British Channel, and the anchorage of the Downs. It was erected in consequence of letters patent granted to Sir Richard Howard by King James I. soon after his succession to the crown of England; but is now the property of the family of Coke in Norfolk, at whose expence it has long since been fitted up on the best principles, as a reflecting light with parabolic silver-plated reflectors. Two years after the date of this patent, another was granted to Sir William Erskine and John Meldrum, to erect lighthouses on the dangerous points of Winterton and Orfordness, in the county of Suffolk, for the direction of the *north fleet*.

These lighthouses, though erected, and a duty levied by public authority, were nevertheless in the condition of what is termed *private* lights, inasmuch as the right of levying the duty was granted to private individuals, who, after defraying the necessary expence of maintaining the light, were understood to reap considerable emolument from the surplus duties; for it does not appear that the corporation of Trinity House had as yet undertaken the construction and direction of lighthouses. Prior to the reign of Henry VIII. this public body seems to have existed under the form of a kind of college or fraternity of seamen, and in the 6th year of that monarch's reign they were incorporated by royal charter, and styled, *The Master, Wardens, and Assistants of the Guild Fraternity, and of the most glorious and undivided Trinity, and of St. Clements, in the parish of Deptford, Stroud, in the County of Kent.*

Queen Elizabeth afterwards granted to this corporation certain privileges of ballastage, beaconage, and buoyage, and empowered them to erect and preserve *beacons* and *signs for the sea*. It does not seem, however, that this public body specially undertook the erection of lighthouses, till about the year 1676. Before this, letters patent were passed generally in favour of the proprietor of the adjoining lands for such erections, which conveyed a right to levy certain duties from shipping for their maintenance. In some cases, the patentee paid an annual sum to the Trinity Board towards the support of their poor; but in other cases it would appear that the patent was granted by the crown, independently of the Trinity Board. As these patents expired, however, this corporation were in the habit of entering upon new leases, or contracts upon the best terms with the respective lessees, though latterly it is believed that this practice has been given up; and the Board now undertakes the erecting and maintaining the lighthouses on the coasts of England without the intervention of any third party, which, as may easily be supposed, has in general turned out much for the benefit of the public, from the very superior style and manner in which these lighthouses are now erected and maintained by that Board; there being, according to the present system, no profit or advantage to be derived by a lessee or contractor, as formerly.

In the early periods of our maritime history, the lighthouse buildings were extremely rude, when the lights were from coal fires, exposed in open chauffers upon the tops of towers of masonry. At what period the combustion of oil was introduced into lighthouses is uncertain. The probability is, that the use of wood as fuel preceded that of pit-coal, as tallow candles preceded oil, to which the aid of the reflector has become conveniently applicable.

In describing the modern lighthouses upon the coast of England, it would not only be foreign to the nature of this work, but would be tedious to the general reader, to enter into minutiæ. We shall, therefore, only make a few remarks applicable to lighthouses in general; and though we shall endeavour to give a list of all the public lights in Great Britain and Ireland, we shall only describe those which appear to be most remarkable for situation; such as the Eddystone in England, the Bell Rock in Scotland, and the South Rock in Ireland. With regard to lighthouses in ordinary situations on the coast, they may be described as consisting of masonry or of brick work, of a greater or less height, according to the elevation of the point or promontory on which they happen to be erected, so as to elevate the light about 100 feet above the medium level of the sea. The accommodation or apartments for the light keepers are sometimes contained within the lighthouse tower. In such cases, the towers are greatly enlarged beyond what is required for the staircase to the light-room. But more commonly there is a separate building for the light keeper and his assistant, consisting of from one to three apartments for each family.

The light-rooms, which were formerly framed of timber, are now constructed wholly of brick or stone, and cast iron frames, with a cupola roof of copper, so as to be perfectly incombustible; and that the light may be obstructed as little as possible, the sash frames are glazed with large plates of polished plate glass.

The light is produced from the combustion of spermaceti oil, with circular wicks or Argand burners placed before reflectors, which were formerly made with facets of glass, but are now constructed of plated copper, framed into the parabolic curve by a process of hammering. The reflectors upon the English coast measure in general 18 inches in diameter over the lips.

The system of management in England, where the lighthouses are under the immediate management of the Trinity Board, and not still in the hands of a lessee or private individual, consist in the appointment of two light keepers, who are paid at different rates, according to the situation of the lighthouse, but may, upon the whole, be stated at about 50 guineas per annum, with a house and fuel; and in some situations, they have more or less ground attached to them, although it rather seems to be a plan of this Board to restrict the attention of the light keepers in this respect. The lights are annually supplied with oil and other necessaries from London, from whence also artificers are sent, for the purpose of making the necessary repairs, under the direction of the engineer for the Board.

We shall here simply enumerate all the public or sea lights upon the coast of England and Wales, without distinguishing those which belong to the Trinity Board, or are specially under its management, as we conceive that Board, in a general way, to take cognizance, more or less, in the proper and regular exhibition of the lights at all the lighthouses upon the English coast. Beginning on the coast of Northumberland, we shall proceed southward by the straits of Dover and the Land's End to the coast of Cumberland.

On the coast of Northumberland, the first lighthouses we meet with are—

The Scares, or *Fern Isles*.—Two revolving and one stationary light.

Tynemouth Head.—One revolving light.

Sunderland Pier.—One stationary light.

Flamborough Head.—One revolving light, with three faces or sides, distinguished by shades of red coloured glass placed before the reflectors of one of its sides, and exhibiting a light of the natural appearance from the other two faces.

Spurn Point.—Two stationary lights.

Dudgeon.—A floating light carrying two lanterns.

Cromer.—One revolving light without colour.

Newarp.—A floating light carrying three lanterns.

Wintertonness.—A stationary light.

Castor.—Two leading lights for Hasborough Gat.

Lowestoffe.—Two stationary or leading lights, placed in a certain direction to guide the mariner between two sand banks.

Orfordness.—Two stationary leading lights.

Harwich.—Two stationary leading lights, the one light being from oil, with lamps and reflectors; and the other from coal, in a glazed light-room. Behind this coal fire a plate of polished brass is set up; and the light keeper is furnished with a pair of large bellows to blow up the fire.

The Sunk.—A floating light carrying two lanterns.

The Nore.—A floating light carrying two lanterns.

North Foreland.—A stationary light.

South Foreland.—Two stationary or leading lights.

Dungeness.—A stationary light.

Owers.—A floating light carrying three lanterns.

Bambridge.—A floating light carrying two lanterns, as a direction for Spithead roads.

Hurst Castle.—Two stationary leading lights.

Portland.—Two stationary lights, the lower light-room having large glass lenses placed before the reflectors.

Caskets.—Three revolving lights.

Eddystone.—A stationary light, now from oil, with reflectors.

Plymouth Sound.—Floating light carrying two lanterns, moored off the Breakwater.

Lizard.—Two stationary lights.

Longships.—One stationary light.

Mumbles.—One stationary light.

Flatholm.—One stationary light from an open coal fire.

Milford.—Two stationary lights.

Smalls.—One stationary light.

The Stack.—One revolving light without colour.

Skerries.—One stationary light.

Chester Bar.—One stationary light.

Hoyle Lake.—Two stationary leading lights.

Bridston Hill, and *Sea Lights*. } Two stationary leading lights.

Liverpool N. W. Buoy.—A floating light carrying three lanterns.

Peel Foudry.—A revolving light without colour.

St. Bees' Head.—A single open coal fire light.

These lighthouses, as before noticed, are of different elevations above the level of the sea, according to the situation of the land on which they happen to be erected, and may, in general, be seen at the distance of from three to six leagues, when the atmosphere is clear. This, however, refers more particularly to the lights exhibited from towers of masonry, as the lanterns of the floating lights cannot with propriety be elevated upon masts more than about 30 feet in height; and the ordinary range at which they can be seen will, with more propriety, be stated at from two to three leagues.

The most remarkable of the numerous lighthouses on the coast of England, both from its position and circumstances which have attended it, is the Eddystone lighthouse. The next in point of difficulty of situation, are the Smalls, the Longships, and the Stack, which we shall describe.

The Eddystone lighthouse, situated at the entrance of Plymouth Sound in the English Channel, is perhaps not less remarkable for its situation upon a small rock in the sea, and the incidents attending the history of the buildings which have been erected upon it, than for the accuracy and interest which has been given to the whole, in Mr. Smeaton's Narrative of that difficult undertaking. In Plate CCCXLVII. we have given sections of the most celebrated lighthouses of France, England, Ireland, and Scotland, drawn to the same scale, of which the Eddystone lighthouse will be observed to be one. This lighthouse is situated upon an extensive reef, well known to mariners as the Eddystone rocks, lying at the distance of 9¼ miles from the Ram Head, or nearest point of land, according to the trigonometrical survey of Great Britain. The erection of a lighthouse on such a spot must therefore have been much desired by the mariner; but the difficulty of the situation rendered this so hazardous an undertaking, that it was long considered impracticable, until the bold and intrepid mind of Mr. Winstanly undertook it in the year 1696, who, after much peril, and encountering many difficulties, in the course of two years completed a building, chiefly if not wholly of timber, on the largest of the Eddystone rocks, which was fixed to the rock by strong bolts of iron. This house was lighted on the 14th of November, 1698; but the experience of the ensuing winter showed, that the sea rose to a much greater height than had been calculated upon; and though the light-room was more than 60 feet above the sea, it is represented as having been at times "*buried under the water*," which induced Mr. Winstanly to enlarge the solid or basement, originally only 14 feet in diameter, and 12 feet in height, to 24 feet in diameter, and the solid was now carried to the height of 20 feet. This building was constructed of a polygonal figure, and is understood to have been partly executed of stone in the lower part, but the upper part was wholly of timber. The original height was 80 feet, including the iron spire work upon the top; but it was now altered, and carried to the height of 120 feet. In this situation it remained till the month of November, 1703, when the building required some considerable repairs, which Mr. Winstanly went off to superintend, when the dreadful storm of the 26th of that month, the ravages of which have been recorded in a publication entitled "The Storm." Among the fatal consequences to the shipping of that day was the loss of the Eddystone lighthouse, which was entirely swept away, with the engineer and all his people! Such was the end of the first building erected upon the Eddystone rocks, and such the melancholy fate of its most enterprizing projector.

We are further informed by Mr. Smeaton's narrative, that the misfortune which had befallen Mr. Winstanly's lighthouse was soon felt by the shipping; for about this time the Winchelsea, a large homeward bound Virginian trader, was wrecked upon the Eddystone rocks, when most of her crew were lost. It was not however till three years after this misfortune, that a new act of parliament was procured by the Trinity House of London for extending their powers, and in 1706, a lease was entered into with a Captain Lovat, who was to erect and maintain a lighthouse, and collect the duties for the space of one hundred years. In the month of July of that year, a new lighthouse was accordingly begun, under the direction of Mr. John Rudyerd of London. In the course of two years, the work was in such a state of forwardness, as to admit of a light being exhibited from it on the 28th of July, 1708, and in the following year the works were completed; to the great satisfaction and happiness of all seafaring people.

The lighthouse, in the lower part, was constructed of alternate strata, or courses of "moor stone rock, granite or gneiss," from Cornwall, and of oak timber. The upper part being framed of timber, the whole was cased or enclosed with strong planks, neatly formed and jointed, to suit the circular plan of the building. Of Mr. Rudyerd's merit in this work we are disposed to judge very highly, in his having executed a plain circular elevation without any superfluous ornament, a circumstance which had not been sufficiently attended to in the former erection; and we are certainly in this respect indebted to him at this day, for having first broken in upon the old practice of ornamental work as unsuitable to the situation of the Eddystone. Mr. Rudyerd's building was founded upon a series of benches or steps cut to suit the dip or sloping inclination of the rock, by which the superstructure rested upon a horizontal basis, to which it was strongly connected with bolts, while the parts of the timber were dovetailed and otherwise connected by spike bolts, and straps of iron applied in the proper directions, from which a strain or force might be expected.

The solid part of this lighthouse was 27 feet in height above the highest part of the rock, excepting a passage of 3 feet in width, and a staircase which measured 6 feet 9 inches square. The entry door being 8 feet above the rock, the ascent to which was by an iron trap ladder. From the top of the rock to the balcony and light-room, this building was 61 feet in height, and, including the light-room and finishing ball on the top, it measured 92 feet in height. The diameter of the base of the building was about 23 feet, and immediately under the balcony and cornice, it measured 14 feet 3 inches. This building was of a circular form, sloping from 23 feet at the base, to about 14 feet at the cornice. The light-room was of an octagonal form, and measured 10 feet 6 inches across. This lighthouse of Mr. Rudyerd's, which had been completed in 3 years, was finished in 1709, and seems to have required little else than the common and ordinary attention to keep it in repair. From the simplicity of the figure of this building, notwithstanding the materials of which it was composed, and the judgment shewn in its construction, it is extremely probable that this building might have withstood the effects of the winds and waves for an unlimited period; for excepting in the year 1744, when a number of the upright timbers were broken up in a violent storm in the month of September, which were speedily repaired by Mr. Jessop, the resident engineer, and father, it is believed, of the late eminent engineer of that name, we hear no more of this building till the year 1755, when it had the misfortune to be destroyed by fire, after a light had been exhibited in it for the space of about 47 years.

An account of this dreadful event is given by Mr. Smeaton in his narrative; and this account the writer of this article had also an opportunity of having corroborated, when he visited the Eddystone in the years 1802 and 1813, by Mr. Tolsher, collector of the customs of Plymouth, who had been an eye witness of the catastrophe. His father was then agent for the proprietors, and at his death he was succeeded by his son, above alluded to, as agent for the Eddystone lighthouse. It appears that the lighthouse had been supplied with necessaries on the 1st of December 1755, the day before the accident, when the light-keepers reported that all was well,—excepting in a late storm, that one of the bricks in the fire place of the kitchen had been loosened by the shaking of the building. It does not appear, however, that the fatal fire had taken place in the lower part of the building,—it is rather supposed to have originated in the light-room, and when the keeper on the watch went to snuff the candles about two o'clock in the morning, he found it full of smoke; and upon opening the balcony door, a flame instantly burst from the inside, and the whole of the upper part appeared in a blaze. In this dreadful state of things, threatened with death by fire on the one hand, and water on the other, the man on the watch flew directly to his companions, who were then fast asleep, and seeing no means of escape, they must altogether have been in a dreadful state of consternation. One of these poor men, who was in the act of looking up to the roof of the light-room at the moment that the lead happened to get into a state of fusion, was not only dreadfully scalded in the neck and shoulders, but, what is truly surprising, a considerable portion of the melted lead entered his mouth, while in a distended state, and passed into the stomach, from which it was after his death extracted, and found to weigh seven ounces 5 drachms.

The disaster having been observed from Plymouth on the morning of the accident, boats went off from all parts of the shore. The first boat went from Cawsand bay, and reached the rock about ten o'clock in the forenoon, when the three lightkeepers were found in a very miserable condition, crowded in the small cavity or hollow on the eastern side of the rock, to shun the pieces of burning timber and red hot iron bolts that were constantly falling from above. There being also a good deal of wind and sea, it was not without great difficulty that these poor creatures were got off the rock into the boat. But they were no sooner landed at Plymouth than one of them fled, and was never more heard of, although it was not supposed that any of them were particularly to blame in this unfortunate affair. There was therefore only the testimony of one person as to the accident of the fire, for the poor man who had swallowed the lead was otherwise so dreadfully scorched, and in such agony during several days that he lived, that he could give no account whatever of the matter; this was the more to be regretted, as he happened to be the light-keeper on the watch when the fire was discovered. Many schemes were thought of, and some were put in practice for extinguishing the fire, and trying at least to save part of the building, but the wind was unluckily just high enough to fan the flame, without being sufficient to raise the sea to extinguish it, and after the flames had raged for several days, nothing of this important building remained but the iron stancheons with which it had been fixed to the rock.

The Eddystone lighthouse had now been twice constructed, chiefly of timber, and we have already seen its defects, either from a want of weight, or the combustibility of the materials. In a third erection upon this fatal rock, it was high time to consider how these defects could be remedied. The late Mr. Smeaton was selected; a man since well known to the public by his valuable writings, and the celebrity which he acquired, not only from the erection of the Eddystone lighthouse, but from many other works of celebrity, during the course of a long practice as civil engineer; of which profession he was actually the father and the founder. Mr. Smeaton recommended stone to be the only material used in the erection of the new house. Such, however, was the prejudice of many well informed persons as to the exclusive fitness of timber for this building, that it was not without considerable difficulty that stone was adopted instead of timber.

Mr. Smeaton's first journey to Plymouth, upon the business of the Eddystone lighthouse, as will be seen from his excellent narrative of the work, was in the month of March 1756, and on the 5th of April, the following month, he landed for the first time on the Eddystone rock, when he found a number of iron bars or bolts fixed in the rock, being the only remains of Mr. Rudyerd's building. Workmen were soon afterwards engaged, and a tender or vessel provided, which was moored near the rock, for the accommodation of the workmen. A work-yard was also procured at Plymouth, and materials collected both from the granite quarries of Cornwall, for the outside casing, and from Portland quarry, for the hearting or interior work of the building. The artificers were formed into two squads or companies, and placed under their respective foremen, who alternately relieved each other at the rock,—the party on shore being employed in the work-yard. In this way the operation continued, until the latter end of the month of November, each party being a week afloat and a week ashore, when the weather permitted this regulation to be followed. The first year was occupied in forming the sloping side of the rock into benches, more regularly than appears to have been done upon Mr. Rudyerd's plan, and into which the stones were let, in a dovetail-form. At this period, the top of the house rock at the Eddystone was somewhat higher than the rise of spring tides, but it was levelled or cut down, so that the first entire course of the present building is nearly upon a level with the high water mark of spring tides.

In the course of the ensuing winter, and following spring, arrangements were made for proceeding with the building operations. A large stock of materials had been provided, and various experiments were made by Mr. Smeaton, with limestone from different parts of the coast, which enabled him to conclude, that a mixture of lime from Abershaw, in the Bristol Channel, and puzzolana earth from Italy, was the proper mortar for this building. A stock of oak trenails was provided for fixing the newly laid stones to the rock, or to the course below, which, with the system of dovetailing and joggling, prevented them from being carried away before the mortar took band, or while the respective courses were in an unfinished state.

Things being thus in preparation for the second year's operations, the attending vessel was moored in her place near the rock, and the foundation stone of the building was laid on the 12th of June, 1757, and by much perseverance, the ninth course, or third entire course above the top of the rock, was completed by the last day of September, with which this season's work was successfully closed.

In the course of this year's operations, many circumstances occurred which will be interesting to the curious, and especially to the professional reader. But as we know that those readers will not be satisfied with the general and abridged account which we are obliged to give in this work, we refer them to Mr. Smeaton's interesting account of this celebrated building; and proceed briefly to notice the operations of the third season.

Owing to several disappointments, the commencement of the work at the rock did not take place till the 2d day of July, 1758, when part of the 10th course was landed, and by the 8th of August the 14th course, or solid part of the building was completed, which brought the work to the entrance door, or to the height of 12 feet above the top of the rock, and by the latter end of September, the 24th course, forming the top of the staircase, and floor of the first apartment or store-room, was laid; which will be more particularly seen in the section of the Eddystone Lighthouse, delineated in Plate CCCXLVII. The work having been continued till the beginning of the month of October, the outward circle of the 29th course, or the arched roof of the store-room, was laid, on which Mr. Smeaton proposed to place a temporary light-room, by which the floating light, which had been moored by the Trinity Board for the last two winters for the direction of shipping, might have been dispensed with. But some different interests, in relation to the collection or property of the light-duties, being concerned, this proposition, which was made by the lessees of the light-duties to the Trinity Board, was not acceded to, and the work was accordingly brought to a close for the season, rather in an abrupt manner; as a gale of wind overtook the workmen, and the tender was put into Dartmouth harbour, and it was not till the latter end of the month of March following that a favourable opportunity was afforded to Mr. Jessop for landing at the rock, when he found every thing nearly in the same state in which it had been left in the month of October, excepting one stone of the upper or unfinished course, which the workmen were in the act of laying, when they were obliged hastily to leave the rock. This stone had been carried away, from its having, perhaps, been left too near the outer verge of the building. But it deserves notice, that the wooden centering, for turning the arch or dome over the store-room, was found in its place, after all the gales of winter, together with a set of wooden triangles, which had been left on the top of the building, and were found, on landing in the spring, to be in good condition, together with a stone which was ready to be laid, and was still found suspended from the tackle.

By the middle of the month of June 1759, in the fourth and last year of the work, the whole of the stones were hewn early in the season, and were ready to ship from the work-yard to the rock. The work commenced this season on the 5th of July, and by the 17th August following, the balcony and upper course of the cornice was laid, which completed the main shaft of the lighthouse, and by the 24th of that month, the 52d or upper course of the parapet wall of the lighthouse was built, which completed the masonry of the Eddystone lighthouse.

Preparations having also been made during the winter months for the light-room, it was prepared in London, and consisted of eight cast iron pillars for containing copper sash-frames for 18 panes of glass each, with a cupola of wrought iron and copper, terminating with a large gilded ball; and on the 29th of September the whole frame of the lighthouse was screwed together and glazed. On the 4th of October, the chandeliers for lighting the house with 24 large tallow candles were hung, and the house being furnished with beds and other conveniences for the use of the light-keepers, it was announced to the public to be lighted on the 16th of October 1759. We may also here remark, that Mr. Winstanly's house was first lighted in 1698, and that of Mr Rudyerd's in 1708.

Since the completion of the Eddystone lighthouse with stone, it has not required any repairs of consequence. But in the year 1807, when the lease of the duties and the property of the lighthouse reverted to the Trinity House of London, it was thoroughly examined for repair by order of that Board. On this occasion also the chandelier and the candles were removed, and in their place a reflector frame was fitted up with Argand burners and parabolic reflectors of silvered copper, to the great and essential improvement of the light. The author of this article experienced this, and is enabled to compare the effect of both lights, having first visited this celebrated work in the year 1802, when it was lighted with candles, unassisted of course by reflectors, and found that it was but very indistinctly seen, in a very good state of the atmosphere, at the flag-staff of the fort near Plymouth. But in 1813, and again in 1818, when he saw this light after it had been converted into an oil-light with reflectors, the effect of the new light was much superior. (See our article EDDYSTONE ROCKS.

Having now given some account of the Eddystone lighthouse, we next proceed to speak of the Smalls lighthouse, which is situated off the coast of Pembrokeshire, about 12 miles in a south-western direction from St. David's Head, on a very dangerous reef of rocks called the Smalls. The rock on which the lighthouse is erected is of considerable extent, and is about six or seven feet above the rise of ordinary spring tides, though the sea occasionally passes over it. We are led to notice this lighthouse, chiefly on account of its peculiar construction, being erected upon nine main pillars or beams of oak-timber, and seven diagonal supports, placed on the landward side of the main beams or supports of the lighthouse, which rise to the height of about 30 feet above the rock on which it is erected. The lighthouse is placed upon the top of these beams, which form a common diameter at the rock of about 25 feet. The whole, tapering gradually towards the top, where they form a diameter of 16 feet, contains an apartment for the light-keepers, and another for the stores, with the light-room over all. There is, besides, a store for fuel, cut in the rock, which is shut with an iron door. In the year 1802, and again in 1818, when the author of this article visited the Smalls lighthouse, he found it undergoing considerable repairs. It had then got a new centre-beam, which, as he was informed, required more frequent repairs than any of the others; from which it is probable that the building rests, and consequently *works* more upon this than upon the others, which must give a degree of unsteadiness and instability to the whole, as indeed was apparent in 1802, the first period alluded to, when, although there was then only what sailors term a fresh breeze, yet he found, while in the light-room, a considerable vibration in the whole fabric. The light-room here is framed wholly of timber, and lined with fire-proof plates of copper. The light is from oil, with reflectors.

In the month of October, 1812, we believe, this coast was visited with a dreadful storm, accompanied with an uncommonly heavy sea, which did great damage upon the coast, particularly on both sides of St. George's Channel and the Irish Sea, when the Smalls lighthouse sustained very material damage. On that occasion the sea is said to have risen to the height of the light-room, and the light-keepers, being under great alarm, broke the glass of the light-room, that the heavy sea might meet with less obstruction. The poor men were taken off the rock after the storm abated, and though their story is understood to have been considerably exaggerated, yet they were found in a very distressed situation, as their provisions had been much destroyed by the storm. The lighthouse after this underwent considerable repairs, and instead of four reflectors, as formerly, it is now furnished with 18 reflectors and Argand burners; a number perhaps fully great for the dimensions of the light-room. The Smalls lighthouse is one of the few lighthouses on the coast which comes under the description of a private establishment, not being under the direction of the Trinity Board. It was erected by Mr. Henry Whiteside, engineer for the company to which the lighthouse and light-duties belong, who, under all circumstances, has very considerable merit in this erection.

The lighthouse called the Longships, is situated about three miles off the Land's-End, upon a singular and almost inaccessible rock, which is about 40 feet in height, with hardly a sufficient surface at the top for the site of the lighthouse. The Longships lighthouse is built of granite from the contiguous shore of Cornwall; the building is about 30 feet in height, containing apartments for the light-keepers, with fuel and the necessary stores for the lighthouse. The light is from oil, with reflectors upon the best construction, and has four light-keepers appointed to it, who take the duty two and two, month about. This lighthouse was originally intended to have been erected and placed upon the Wolf rock, a reef attended with circumstances of much danger to shipping, and for the site of a lighthouse one of the most important stations on the coast of England. With the view of erecting a light on the Wolf rock, the Trinity Board appear to have granted a lease, or obtained a licence for a Lieutenant Smith of the Royal Navy. But either from the difficulty of the situation, or what is not improbable, the much greater expence which would have attended an erection upon the Wolf than on the Longships, the lessee proposed, and obtained an alteration in the site from the Wolf to the Longships-rock, which is only three miles from the shore, instead of about twelve miles, the distance of the Wolf from the Lands-End. It was accordingly determined that a lighthouse should be erected upon the Longships, and a beacon upon the Wolf rock. Both of these were executed, but the latter was soon afterwards thrown down by the sea, and although the beacon has obtained a place in many charts of the coast, the rock is really without any thing of the kind to distinguish it, as the writer of this article landed upon it in the year 1813, from the Orestes sloop of war, Captain Smith, and again from the lighthouse yacht in 1818.

The Stack lighthouse is erected upon a small island called the South Stack, which is separated only about 30 feet from the main island of Anglesia, about six or seven miles from the town and harbour of Holy Head. This lighthouse is only remarkable for the singularity of its position, upon a small precipitous islet, containing only space for the lighthouse and a small garden, elevated about 150 feet above the sea.

The approach to the lighthouse from the land-side is curious, and does much credit to the ingenuity and contrivance of Mr. Evans, the Trinity agent at Holyhead. The visitor descends from the Main island by a flight of about 400 stone steps to a bridge of ropes about 100 feet span, which is extended across a deep chasm of the sea to the Stack island; the whole having a singular and somewhat romantic appearance. These works must have been attended with considerable difficulty and expense; but are indipensably necessary, as the light-keepers have their supply of water, &c. by passing along the bridge of ropes. At this lighthouse station there are two light-keepers, who, it is believed, have each £60 per annum, with fuel, &c. and have each three or four apartments for their families. It is also worthy of remark, that from the exposed state of the buildings, the rain water, in stormy weather, was found to come through the walls into the buildings. After trying several plans for making the walls water proof by roughcasting, &c. the most effectual method was found to be that of painting the rough ruble walls with oil paint, and while in a wet state they were *dusted* over with clean sharp sand, which has rendered them perfectly water tight, after many other methods had failed. Painting and sanding the outward walls of buildings is not new, but we believe it has not been often resorted to in ruble buildings with such good effect as at the Stack lighthouse.

Scotland.

Although the lighthouses of Scotland, considered as a general system, under the management of a public Board, entitled *The Commissioners of the Northern Lighthouses*, is comparatively of late institution, yet a considerable number of these useful buildings have long been erected on various parts of the coast. The benefits and advantages experienced by a similar establishment on the coast of England naturally led to the institution of the Northern Lighthouses. But we must always keep in mind, that the formation of a system of this kind in a country must be preceded by the increased capital of its merchants. Accordingly, about the year 1780, when the trade of Scotland had made considerable advancement, and when the great landed proprietors had turned their attention to the improvement of their estates, instead of quarrelling about their feudal rights, every thing connected with the advancement of the fisheries, for the extension and opening of the navigation to the Highlands and Islands of Scotland, became an object of importance both to the government and to the landed interest. It was consequently proposed to form a Board in Scotland for the erection and maintenance of lighthouses on the shores of the northern parts of the kingdom. This measure originated with the convention of the Royal Burghs of Scotland at their annual meeting, when the heads of a bill were drawn up and brought into parliament by the late Mr. Dempster of Dunnichen, member of parliament for the burghs of Dundee, &c. This bill passed into a law in 1786, appointing the crown lawyers of Scotland, the sheriffs of certain maritime counties, and the chief magistrates of the principal Royal burghs as commissioners of the northern lighthouses. Four lighthouses were accordingly erected, viz. one on the coast of Aberdeenshire, one on the Orkney islands, one on the Harris Isles, and one upon the Mull of Kintyre in Argyleshire. But we shall here give a particular list of all the lighthouses upon the coast of Scotland as we have done on the coast of England; beginning at the frith of Forth on the east coast, and so proceeding northward to the frith of Clyde and Isle of Man in the Irish sea.

Inchkeith.—A revolving light, without colour, or of the natural appearance.

Isle of May.—A stationary light, originally from the combustion of pit-coal, but now from oil with reflectors.

Lights of Tay.—Two stationary leading lights.

Bell Rock.—A revolving light, with red coloured shades.

Kinnaird Head.—A stationary light.

Pentland Skerries.—Two stationary lights.

Hart Point of Sanda.—A revolving light, without colour.

Island Glass.—A stationary light.

Mull of Kintyre.—A stationary light.

Pladda.—Two stationary lights.

Cumbrae, in the river Clyde.—A stationary light.

Toward Point, in the Clyde.—A revolving light.

Clough.—Ditto, a stationary light.

Corsewall.—A revolving light, with coloured shades

Port-Patrick.—A stationary light.

Point of Ayr, Isle of Man.—Now erecting, to be a revolving light, with coloured shades.

Calf, Isle of Man.—Now erecting, to consist of two revolving and leading lights, without colour.

The lights above enumerated, belonging to the shores of Scotland, are maintained by the combustion of oil with reflectors; some of these first erected are still lighted with common lamps, aided by reflectors formed to the parabolic curve with facets of glass; but those of later construction have the Argand burner, with reflectors of silvered copper, also raised to the parabolic curve, which in general measure 24 inches in diameter over the lips. The light-rooms, at least of more modern construction, are fitted up of incombustible materials; the floor and side walls of the parapet being of stone, and the window-sash frames are of cast iron, and the roof of copper. The sash frames are also glazed with plate glass, measuring about 30 inches in height, and 27 inches in breadth.

The lights above enumerated are under the immediate direction of the Lighthouse Board, excepting those of the Tay, which belong to the Trinity House of Dundee, and those of the river Clyde, which belong to the trade of Glasgow; and the light of Port Patrick, which is connected with the passage to Ireland, and is placed under the direction of the commander in chief of the forces of Scotland. In Plate CCCXLVII. we have given a section of the Bell Rock lighthouse, on the same scale with those of the Tour de Corduan, and the Eddystone lighthouse, &c. In Plate CCCXLVIII. an elevation of the leading lights of Tay is given; and in Plate CCCXLIX. we have delineated a plan and elevation of the lighthouse at Inchkeith, intended to represent a complete establishment of this kind, and these we shall endeavour to describe as specimens of the Scotch lighthouses.

In a former volume of this work, under the article **Bell Rock**, we have given a description of this most dangerous reef, a sunken rock, which is described as lying at the distance of 11 miles from the promontory called the Red Head in Forfarshire, or nearest land. The rock itself measures about 427 feet in length and 230 feet in breadth, and is about 12 feet *under water* at the ordinary height or perpendicular rise of spring tides. This rock is one of the most dangerous, in point of situation, that is to be met with on the coast of Great Britain; for while it lies in one of the most frequented estuaries or friths in the kingdom, it is much lower in the water than any rock on which similar buildings have been erected: and the mariner could formerly have little or no warning of his danger when in its vicinity. The Bell rock was therefore long considered as the chief obstruction to the navigation of that important estuary, the Frith of Forth, and, for ages, the want of some distinguishing mark to point out its place was lamented. This rock, or most dangerous reef, is noticed in the voyage of King James V. of Scotland, and tradition says that the Abbots of the ancient monastery of Aberbrothwick succeeded in fixing a bell upon it in such a manner that it was rung by the impulse of the sea so as to warn mariners of their impending danger. It is also said, though with little probability of truth, that the crew of a ship carried away the bell, and that they were all lost upon the Bell rock on a future voyage. Be this as it may, the rock, as far as authentic record or the memory of man carry us, has been without any permanent mark to distinguish or point out its place, till the period of the erection of the lighthouse of which we are now treating. This measure was more eagerly looked for after the appointment of a Board for the erection of lighthouses in Scotland; but such were the difficulties of the undertaking, and the unavoidable expense attending it, that it was a considerable time before the funds of this Board were in any condition to enable it to undertake a measure of so much difficulty and expense; and it was accordingly allowed to lie over from time to time. In the winter of 1799, however, the eastern coast of Great Britain happened to be visited with a dreadful storm, when no less than about 70 vessels were wrecked upon the coast of Scotland. This calamity created such a sensation in the minds of all ranks of the community, that the attention of the Lighthouse Board was more immediately directed to this object; and a bill was accordingly brought into parliament in the year 1802, by the Right Honourable Lord President Hope, when he was in parliament, and a member of the Lighthouse Board, as Lord Advocate of Scotland. This bill had for its object to enable the commissioners of the northern lighthouses to levy certain additional duties, and empower them to borrow a sum of money for this work; but the bill did not pass into a law till the year 1806, when the Honourable Henry Erskine, then Lord Advocate of Scotland, brought a new bill into parliament, and the commissioners immediately undertook this highly important work.

Various plans were then under the consideration of the Lighthouse Board; for, while some were of opinion that it was a work wholly impracticable, others, as the late Captain Brodie, in a very ingenious manner, proposed a structure to be erected upon pillars of cast iron. Mr. Murdoch Downie, a late eminent marine surveyor, likewise brought forward a plan for a building to stand on pillars of stone. When the commissioners of the lighthouses, however, resolved in the year 1800 to undertake this work, they directed Mr. Stevenson, their engineer, to survey the Bell rock, and to report upon the practicability of erecting a building upon it. Mr. Stevenson having accordingly reported this as a practicable work of stone, similar to that of the Eddystone lighthouse by the late Mr. Smeaton, the commissioners submitted the whole plans before them to the consideration of Mr. Rennie, an engineer of acknowledged eminence, who entirely concurred in opinion with Mr. Stevenson, that a lighthouse of stone, upon the principles of the building on the Eddystone, was the most suitable for the situation of the Bell rock; and a work upon the same plan was proceeded with accordingly.

The act of parliament for the erection of the Bell rock lighthouse passed in 1806, having provided for a loan to the lighthouse Board of £25,000, and as the Board were in possession of surplus duties to the amount of £20,000, they were thus in possession of £45,000 of cash in hand, for the purposes of the work, besides the surplus duties which might be expected to arise during the progress of the work: With these funds measures were accordingly taken for proceeding with it, as soon as the act passed.

The season having been too far advanced last year, after the passing of the act, for commencing any operation at the Bell rock, all that could then be done was to make the necessary preparations for proceeding with the work in the summer of 1807; and the commissioners having been authorised to collect duties upon the exhibition of a floating light, the first measure adopted was to provide such a vessel as might answer the double purpose of a floating light and a tender for the artificers employed in the erection of the lighthouse. A Dutch fishing vessel was provided and moored off the Bell rock, in the month of July, at the distance of about two miles from the rock, in a north-westerly direction, in a depth of about 20 fathoms water, which is double the depth that any of the floating lights upon the coast are moored. Her crew consisted of a master, and eight seamen and a boy. She was only about 80 tons register, but it was necessary that she should be well provided with able seamen, in case of accidentally drifting from her station; and as her moorings, which consisted of a lage *mushroom anchor* of cast iron, so called from its resemblance to the vegetable of that name; she had likewise a chain of 50 fathoms in length, which was made of strong iron bars, of 1½ inch in thickness, to which an hempen cable was attached, which was veered out more or less according to the state of the weather. It was therefore necessary that a strong crew should be on board, to enable them to *sight* or lift their moorings after every gale of wind, to see that all was right.

This vessel was rigged with three masts, on each of which a lantern was made to collapse and to traverse upon it; so that the light could be seen in all directions, thereby preventing the necessity of having heavy yards, for the suspension of ponderous lanterns. This new plan was, in other respects, found to be of very great advantage in the course of the four years during which the floating light was exhibited as a temporary light off the Bell Rock.

A work-yard for preparing stones and other building materials having been provided at Arbroath, the most contiguous harbour on the adjacent coast, a quantity of granite was procured from the quarries of Mr. Skene of Rubislaw, at Aberdeen, for the outside casing, and also of sandstone from the quarry of Mr. Mylne of Mylnefield, situated near Dundee. In the work-yard at Arbroath, shades were accordingly fitted up, and barracks erected for the workmen, that they might at all times be at hand, by night or day, for going off to the Bell Rock. Implements and machinery for lifting heavy blocks of stone were also provided, and artificers were employed, under proper foremen, for proceeding with the work.

Operations having been thus brought into a train of forwardness ashore, Mr. Stevenson, under whose direction the work was executed, embarked with a number of artificers upon the 17th day of August 1807, and began the work upon the Bell Rock. The first employment at the rock, was to bore a sufficient number of batt holes for fixing the lower ends of six large beams, and six of a smaller size, for the support of a wooden beacon, or temporary residence on the rock for the workmen during the summer months. Such a work was found to be indispensably necessary, not only to give confidence to the workmen while upon the rock, in case of accident to any of the attending boats, but was otherwise of immense advantage, both to the safety of the artificers, and to give much facility to the work. It consisted of beams of Memel timber of about 50 feet in length, ranged in a circular manner, forming a diameter of 36 feet at the rock, and meeting together at the top, where a wooden house, consisting of three floors, was erected. One of these floors was occupied as a cook house and provision store; the second, which was much encumbered with the meeting of the principal beams, formed only two cabins or apartments, one for the engineer, and the other for the foremen of the work. The upper or third compartment of the beacon-house was wholly occupied as a barrack room, in which three rows or tiers of beds were fixed, which made it capable of containing about 30 artificers. Below the apartments just described, there was a floor of a more temporary nature, which was fixed at the height of 25 feet from the rock. On this gallery or floor the mortar was prepared; but it was otherwise particularly useful as a forge or workshop for the smiths, where the picks and irons were sharpened, for preparing the foundation, with much facility and advantage to the work. On several occasions the violence of the sea lifted this floor, when not only the lime casks and lighter apparatus, and the floor itself, was set a drift, but even the smiths' anvils and implements were to search for upon the rock at low water, upon the return of good weather. Yet during the five years that this beacon was found useful and necessary to the operations, none of the batts appeared to be in the least degree shaken, although the beacon was immersed every tide from 8 to 12 feet in water.

The labours and hazard of this season's operations were very considerable, having every tide to go to and from the rock to the floating light in row boats, containing 16 people each; and on many occasions, when the wind shifted suddenly, it was with great difficulty that the boats could be rowed to the floating light or tender, situated about two miles distant from the rock. This kind of service was only to be overcome by much perseverance, and by a kind of management which was happily effective, and which Mr. Stevenson encouraged by his own example, as he remained constantly with the artificers at the rock during the first season's operations.

During the winter months, and while the operations could not be proceeded with at the Bell Rock, the whole of the artificers were employed in the work-yard, where the stones were all prepared, and laid course by course upon a stone platform or basement, equal to the foundation course of the lighthouse. Here the stones were fitted into their places, and carefully numbered and marked as they were to lie in the building; an operation which was indispensably necessary, the several courses being dove-tailed and connected together, so as to form one mass from the centre to the circumference of the building. The stones were also bored or fixed with trenails of oakwood and joggles of stone, after the manner of the Eddystone lighthouse, and in this prepared state they were laid aside, and in readiness for being shipped in lighters for the Bell Rock. The operations of the second season commenced at the rock as early as the weather would permit. The work consisted chiefly in laying tracks of cast iron railways from the several leading places to the site of the lighthouse, for the conveyance of the materials to the building. These preparations, together with the fixing of cranes and other apparatus, having been got in readiness, and the foundation pit or site of the lighthouse having been excavated in some places to the depth of 5 feet below the rock, the first stone was laid upon Sunday the 10th of July. In the course of this current season four courses were laid, viz. the first consisting of detached stones, for bringing the foundation to a uniform level, besides three entire courses, which brought the building to the height of 5 feet 6 inches above the lowest part of the foundation pit.

The works of this season went forward with much facility; and the beacon, a temporary wooden house, having withstood the storms of the former winter, gave such confidence to the landing operations at the rock, that there was no hesitation on the part of the artificers as to the practicability of landing at any time, if the boats could be got out of the tender in safety; but the vessels often rolled so heavily, that, in hoisting out the boats, there was great risk of staving or damaging them. Another advantage which attended the work this season, was a new vessel which was provided as a tender for lodging the artificers off the rock, instead of the Floating Light. The advantage of the new tender, called the Sir Joseph Banks, (in compliment to the eminent baronet of that name,) was, the facility with which she could be cast loose from her moorings, and brought to the lee side of the rock, whereas the Floating Light, being moored as a guide to shipping, was quite unhandy, and could not thus be removed at pleasure when wanted for the use of the artificers.

The works of 1809, or third season, commenced, in the spring of the year, by laying down mooring chains, with floating buoys, for mooring the stone lighters and flush-decked praam boats employed in landing the stones upon the rock. After much labour, the lighthouse was got to the height of 30 feet early in the month of September of this year, being the height of the solid part of the building. By continuing the operations for a month or two longer, the lighthouse might have been got to a considerably greater height, though not without much risk to the operations; yet, as Mr. Stevenson foresaw the practicability of completing the whole works in the course of the following season, he thought it more advisable to leave the house in this defencible posture, after having completed the solid part, on which the sea had much less hold, than if part of the void or hollow of the lighthouse had been built.

The anxiety to proceed at an early period of the season, so as to get the masonry of the lighthouse completed, and the light-room fitted up in good weather, may easily be conceived. The masonry of the building had attained one-third part of its height; and although the greatest proportion of the solid contents had been built, it had required the work of three years, its progressive height having in some measure brought along with it corresponding difficulties. Notwithstanding these, the masonry was got to its full height of 100 feet by the month of October, and in December the light was advertised to the public for exhibition on the 1st February 1811; when the temporary floating light was discontinued: and thus happily terminated the erection of the Bell-Rock lighthouse, without the occurrence of any serious accident to retard its progress.

The Bell-Rock lighthouse is a circular building, measuring 42 feet in diameter at the base, and 13 feet in diameter at the top. The masonry is 100 feet in height, and including the light-room, it measures about 115 feet. The ascent from the rock to the top of the solid or lowest 30 feet, is by means of a kind of trap ladder, which is ascended with great celerity by the light-keepers, but forms rather a difficult path for strangers, who are generally hoisted up to the entrance-door in a chair by a moveable crane of a singular construction, which projects from the building. The ascent from the level of the entrance-door is by means of a circular stair to the first apartment, containing the water, fuel, &c. From thence to the several apartments, the communication is by wooden steps to the other apartments, as will be better understood from the section of the building given in Plate CCCXLVII. to which we refer the reader for the thickness of the walls and other particulars. He will further have an opportunity of comparing these, together with the depth of water in which the principal buildings of similar construction are founded, being there delineated and drawn to the same scale. The stones of the Bell Rock lighthouse, as before noticed, are dovetailed, and the several courses connected by means of joggles of various dimensions, and with oaken trenails two inches in diameter. The whole courses were also laid in mortar, consisting of equal measures of pozzolana earth, pulverised lime, and sharp sand.

The three lower apartments of the lighthouse have two windows each, but the upper rooms have each four windows. The windows have all double sash-frames, glazed with plate-glass, besides a storm-shutter of timber for the defence of the glass against the sprays of the sea; for although the light-room is about 88 feet above the medium level of the tide, and is defended by a projecting cornice or balcony, with a cast iron rail, formed like the meshes in net-work, yet the sprays of the sea occasionally lash or fall upon the glass of the light-room, so that it becomes necessary, in gales of wind, to shut the whole of the dead lights to windward.

The coal or fuel for the use of the lighthouse kitchen is contained in a piece of framed work made of cast iron, and the water is also kept in metal tanks coated with pitch, which answers so well for the preservation of water, that at the Bell Rock it is generally sweet and agreeable. In the floor or room immediately above the water and fuel-store, is the store for the oil, which is contained in cisterns of copper, coated with tin. The next in order, as we ascend, is the kitchen, where there is an open fire-place of cast iron, from which the smoke is conveyed in a cast iron pipe through the several apartments above, without being included in the walls of the building, which are consequently not weakened nor liable to injury by the void of the chimney. The whole of the timber work of the partitions, beds, and chairs, &c. is of wainscot.

The light-room is of an octagonal figure, measuring 12 feet across, and 15 feet in height. It is framed of cast iron, and glazed with polished plate-glass, each plate measuring 2 feet 6 inches by 2 feet 3 inches, and is about one fourth of an inch in thickness. The light-room, which was framed and prepared at Edinburgh, is covered with a dome roof, and terminates with a circular ball, as will be seen from the section or engraving in Plate CCCXLVII.

The light of the Bell-rock is from oil, with Argand burners placed in the focus of silver-plated reflectors, hollowed with a wonderful degree of accuracy to the parabolic curve, simply by the process of hammering. These reflectors measure twenty-four inches over the *lips*; and the light is so powerful, as to be seen and readily distinguished at the distance of six or seven leagues when the atmosphere is clear.

The Bell-rock light may easily be distinguished from all others upon the coast, as it shews the natural or common bright light, alternately with a light of a red colour, tinged by the interposition of plates of glass stained red, which are placed between the observer and the reflector. These reflectors are ranged upon a frame with four faces or sides; two of these sides being fitted up with coloured shades, while the frame is made to revolve upon a perpendicular axis, by means of a train of machinery, and thereby exhibits alternately a red-coloured light, and a bright light of the natural appearance. Between these appearances, and in the course of each revolution, there are intervals of darkness, which in a very simple and beautiful manner mark out this lighthouse to the mariner from all others on the coast.

The same machinery is used for tolling two large bells night and day during the continuance of foggy weather. As these bells weigh about 12 cwt. each, they are heard at a considerable distance, so as to alarm and give warning in thick and hazy weather to the mariner on his approach to the rock, when the light and lighthouse may be hid in fog.

In the economy, or keeping of the Bell-rock lighthouse, four light-keepers are appointed, three of whom are always at the lighthouse, and one, in his turn, is ashore on liberty. When the weather will permit of regular turns of removal, the light-keepers are six weeks at the rock, and a fortnight ashore with their families. The pay of the principal light-keeper is 60 guineas per annum; the principal assistant has 55 guineas, and the other two assistants have each 50 guineas. When on duty at the rock, the light-keepers have each a stated allowance of bread, beef, butter, oatmeal, pot-barley, vegetables, and small beer, together with 4d. a-day each for tea and other necessaries. Besides their stated salary, they have each a suit of uniform clothes every third year.

The most contiguous town on the opposite coast, as before mentioned, is Aberbrothwick, or Arbroath, in Forfarshire, about eleven miles distant, where buildings are erected for the accommodation of the families of the light-keepers, consisting of two or three apartments for each. Here also the master and crew of the attending vessel reside, and the several families have each a piece of enclosed ground, and a seat in the parish church. Connected with the lighthouse-buildings at Arbroath, there is a signal tower 50 feet in height, the top of which is formed into an observatory-room, with an excellent achromatic telescope placed upon a stand; and from this tower corresponding signals are arranged and kept up with the lighthouse.

The Bell-rock tender is a very handsome cutter, of 50 tons register, carrying a model of the Bell-rock lighthouse upon her prow; and she is appropriately named the Pharos. Her station is at Arbroath; and although she makes occasional trips to other lighthouses on the coast, she visits the Bell-rock generally at new and full moon, or at spring tides, with necessaries, and for the alternate change of the light-keepers. The Pharos is navigated by four seamen, including the master; and she carries a boat of sixteen feet in length at the keel, being of sufficient dimensions for landing the stores at the rock in moderate weather. The master of this vessel acts as superintendant at the Bell-rock, and has the charge of the buildings and stores kept at Arbroath.

The Bell-rock lighthouse, with the buildings at Arbroath, attending vessel, and first year's stores, are understood to have cost about 60,000*l.* Whether, therefore, we consider the importance and utility of this lighthouse, situated upon one of the most frequented coasts, and leading both to the friths of Forth and Tay, the former being one of the chief anchorages in the kingdom, or contemplate the difficult and arduous nature of this undertaking, we shall, in both cases, find it to be one of the most important undertakings of the reign in which it was erected: For, while we were yet employed in a long and expensive war, it is not a little gratifying to contemplate the resources of Great Britain, when such a sum could be expended in the department of lighthouses, for the erection of a single improvement in the navigation of this part of the coast.

With regard to the northern lighthouses, of which the Bell-rock forms one, it may be stated, with the excepception of that lighthouse, that the others are erected either upon *points* or *promontories* connected with the mainland, or upon the islands lying off the coast of Scotland, including the Isle of Man.

Some of these, as the Mull of Kintyre lighthouse, on the coast of Argyleshire, is almost quite inaccessible by sea, from the precipitous and difficult nature of the surrounding shores; while it is hardly less accessible by land, from the mountainous state of that district of country. The nearest town to this station is Campbellton, which is about seventeen miles distant; and, with the exception of a single shepherd's house, there is no dwelling within five miles of it. This lighthouse is situated upon the face of a mountain, about 240 feet above the level of the sea, but the land is still much more elevated above the lighthouse; so that it forms a continued descent of about five miles from the top of this mountain to the village of Southend. So difficult, indeed, is the access to this lighthouse, that the house where the stores are landed from the vessel is situated about six miles from the lighthouse, from which the oil and other necessaries have to be carried on horseback over the mountain. In building operations and repairs, the expence is therefore very considerable, as, from the difficulty of the road, little more than 1 cwt. becomes a load for a horse; and a single journey from the storehouse to the lighthouse is a day's work.

Of the northern lighthouses situated upon islands, that upon the Pentland Skerries in Orkney may be considered the most inaccessible on the coast. These skerries consist of two islands, with an extensive reef of sunken rocks. One of them is by computation about 15 acres, and though it is about 25 feet in height, the sea has been known to make a passage over it, and strip it entirely of its soil. This small island is consequently uninhabited; but it is much frequented by numerous seals, cormorants, and other wild fowl. The other island, called the Great Skerry, on which the lighthouses are erected, is a flat island, sloping gently towards the southwest. It measures about 75 acres, has a uniformly flat surface, and is of a circular form. The rocks of this island consist of sandstone flag, which is the common rock throughout the Orkney islands. The stratification of the Pentland Skerries is simple, and is arranged in the most perfect order, observing throughout the same dip and inclination as at the surface. Towards the northwest, where highest, the surface of the island is 45 feet above the medium level of the sea. Here it is quite astonishing to observe the impression which the sea has made, and is still making upon this island, which is hollowed out in some places into caverns, and in other places into large square compartments of two or three hundred feet, as flat in the bottom as if laid by the hands of man, and as perpendicular on the sides as works in house building. In the course of these ravages of the sea, the author of this article has measured several blocks of stone weighing from two to five tons, which have been driven or forced up an inclined plane formed by debris, to the top of the island. This island is placed in the very middle of the Pentland Frith, about three or four miles from the opposite shores of Caithness, on the mainland of Scotland, and the island of South Ronaldshay the southernmost of the Orkneys: the Pentland Frith is well known for its tempestuous seas, and cross running tides; and it is only in certain directions of the wind, and a very calm state of the sea, that its lighthouse can be approached with any degree of safety.

Having made these general remarks upon two of the most difficult of the stations of the northern lighthouses, the one upon the mainland of Kintyre, and the other upon the island of Pentland Skerries in Orkney; we shall take leave of the northern lighthouses, by referring to Plate CCCXLIX. on which an elevation and plan of the lighthouse and offices on the island of Inchkeith, in the Frith of Forth, are delineated. The following are the references to the section of the light-room, in Plate CCCXLIX. A, Revolving reflector frame. B, Time-piece for regulating the motion of the machinery. C, The machinery. D, Barometer. This instrument, together with a thermometer and rain-gage, is attached to each of the northern lighthouse stations. E, Weight of the machinery. This lighthouse was erected when the late Mr. Smith was engineer to the lighthouse board; which will be sufficient to shew the kind and measure of accommodation connected with the establishment of the northern lighthouses. At some of the first erected of these, however, the accommodation is perhaps less complete, having been originally erected for one family; but since the appointment of an additional attendant or assistant for each lighthouse, it has been found necessary to enlarge the dwelling houses. The salary of a principal light-keeper in the service of the commissioners of the northern lighthouses, may be stated at from 45*l.* to 60 guineas per annum, according to the nature of the situation and importance of the respective charge; and that of an assistant light-keeper at from 35*l.* to 50*l.* with a suit of uniform clothes once in three years; besides a house and a sufficint allowance of fuel, there is attached to each lighthouse not less than 10 acres of ground, so as to afford a cow's grass and garden for each light-keeper. This system we humbly conceive to be attended with great advantage to the light-keepers, not only from the comfort it affords to their families on these forlorn and sequestered situations, but also from the healthful employment it provides for them during the summer months, when their duty is comparatively easy. The time of these men is thus fully and usefully occupied, on the spot, both in summer and in winter; while their leisure hours would otherwise be lost in idleness and ennui.

IRELAND.

The lighthouses on the coast of Ireland were originally placed, by act of Parliament, under the management of the Board of Customs at Dublin; but in the year 1810, by a new act, they were put under the direction of a special board, consisting of the principal merchants of Dublin, under the title of *The Corporation for Preserving and Improving the Port and Harbour of Dublin.* The exertions of this Board in the lighthouse department, both in the improvement of the old, and in the erection of new lighthouses, have been most active, and are highly deserving of the consideration of those concerned in nautical and commercial affairs. On the shores of this rapidly improving country, we can now reckon no fewer than 26 lighthouses, including harbour lights, as appears from the following list of lighthouse stations. About 15 of these have actually been established by this corporation, while the remaining 11 have either been rebuilt, or refitted with new reflecting apparatus; and all this has been accomplished in the short space of about eight years!

Beginning at the port of Dublin with the enumeration of these lighthouse stations, and proceeding southward, the first we meet with is upon the pier-head of Dublin, commonly called the *Pigeon-house*, of which we have given an elevation in Plate CCCXLVIII. The next is

Dunleary Pier-head—One stationary light.
Poolbeg—One stationary light.
Wicklow—Two stationary lights.
Tusker—One revolving light, with red coloured shades.
Hook Tower—Two stationary lights.
Cork Harbour, or *Roche's Point*—One stationary light, with red-coloured shades to *seaward.*
Duncannon Fort—One stationary light.
Old Head of Kinsale—One stationary light.
Charles Fort, at Kinsale harbour—One stationary light.
Cape Clear—One revolving light, without colour.
Loop Head—One stationary light.
Arran Island, Galway Bay—One revolving light, without coloured shades.
Mutton Island, Galway Bay—One stationary light.
Clare Island, off the coast of Mayo—One stationary light.
Annanmore, off the coast of Donegall—One stationary light.
Fannel Point, Lough Swilly—One stationary light, with red-coloured shades to seaward.
Innistrahull—One revolving light, without coloured shades.
Copeland—One stationary light.
Kilwarlin, or *South Rock*—One revolving light, without coloured shades.
Ardglass—One stationary light, with red-coloured shades to seaward.
Cranfield—One stationary light, with an additional light as a direction for certain depths of water in the harbour.
Balbriggan—One stationary light.
Houth Pier-head—One stationary light.
Houth Bailey—One stationary light.
Kishbank floating light, moored off Dublin Bay—A vessel carrying three lanterns.

Besides the lighthouses here mentioned, others are about to be erected on this coast. Several of those above enumerated are *harbour* lights, which, in Ireland, are placed under the direction of the Lighthouse Board, which is not the case either with the English or Scottish harbour-lights. That it should not be so is perhaps to be regretted, as the power of erecting lighthouses without adhering to a proper and uniform system will, in all probability, eventually lead to much confusion. It would therefore be a matter of great public benefit, if the power of the latter Boards were extended to all *lights* and *sea-marks*, of whatever nature, upon their respective coasts. This observation will appear the more forcible, when we call to our recollection the loss of two of his Majesty's frigates, the Pallas and Nymph, in the Frith of Forth, in the year 1810, (a loss to the country of perhaps not less than 200,000*l*., besides several valuable lives,) by their mistaking the fire of a lime-kiln on the shores of East Lothian for the light on the island of May, then an open coal fire.

From the similarity of the Irish plan of lighthouses with that of the British, it becomes unnecessary here again to enter upon any general description of the construction of the houses, or of the reflecting apparatus. We shall, therefore, as we have before done under the heads of England and Scotland, proceed to describe, as far as our information goes, one or two of the principal lighthouses on the coast of Ireland. The first erected lighthouses on this coast, were perhaps those of Dublin harbour, Hook Tower, at Waterford harbour, and Copeland Island, for the direction of the shipping of Belfast. These early lights were originally maintained from the combustion of pit-coal, in open chauffers like those of the same day in England and Scotland. But excepting the light of St. Bee's Head, in Cumberland, and Flatholm in the Bristol channel, and one of the Harwich lights, it is believed that the whole lights on the coasts of the united kingdom, are now from oil, fitted up with reflecting apparatus.

The most remarkable lighthouse on the Irish coast, in point of situation, is the Kilwarlin, or South Rock lighthouse, lying off the coast of Downshire, and near the entrance to Loch Strangford; a station of great importance to the navigation of the Irish Channel, from some very dangerous rocks which lie much in the way of ships sailing to and from the great ports of Liverpool and Dublin, &c. This lighthouse was originally built by the Commissioners of his Majesty's Customs in Ireland, when the lighthouses of that coast were under their direction. It stands upon an extensive reef, lying about three miles from the shore. Part of the rock is at all times above the perpendicular rise of the tide, but the foundation of the lighthouse is only about four or five feet above low water of spring-tides. The south rock consists of slate-clay schistus, intermixed with strata of clay, and is therefore liable to be much broken up by the violence of the sea. The foundation of this building has accordingly occasioned some trouble since it was finished, in securing it with an exterior border or pavement of granite.

The South Rock lighthouse was the work of the late Mr. Rogers, Engineer for the Board of Customs. It was founded in 1795, and when the writer of this article visited the work in the spring of 1796, the building was about 16 feet in height, and considerably above the rise of the highest tides. It is built of blocks of granite, brought partly from the quarries in the neighbourhood of Wicklow, and partly from the mountains of Morne in the vicinity of Newry. The end joints of the outer circle, or tier of stones, are joggled into each other in a very secure manner. The solid part of the building is still farther united, by means of eight bars of iron, about three inches square, which are carried up in the interior of the work; on the top of every third or fourth course a strong circular plate of iron is laid horizontally, and through these plates the upright bars are made to pass, and are strongly *keyed down* upon the several courses, by means of which the whole is firmly connected together.

The elevation or form of this lighthouse, as will be seen from the perpendicular section of it, delineated in Plate CCCXLVII. is that of the frustrum of a cone. The solid part is 22 feet in height; to which the ascent from the rocks is by means of a wooden ladder, which is drawn up into the building when the tide flows. At the sole of the entrance door, a *platt*, or large stone, with an iron railing, projects from the building, for the conveniency of stepping from the ladder into the door, which in such a situation, where it can be introduced with safety to the building, is of great use. Within the lighthouse, the ascent from the entrance-door to the store for fuel, oil, and other necessaries, is by a stair with stone steps. Over the store is a kitchen, and above it a bed-room; and over this the lighthouse is erected upon a parapet-wall of stone, in the usual manner: the ascent from the one to the other of these apartments is by means of wooden ladders. The light here is on the revolving principle, and has lately had an entire new train of machinery, moved by a weight, fitted up by the Corporation for improving the port of Dublin. This apparatus has been made applicable both to the turning of the reflector-frame, and to the tolling of a pair of large bells, night and day, during the continuance of thick and foggy weather. The light here, in common with the other lights on the coast of Ireland, is from oil, aided with parabolic reflectors of silvered or plated copper, constructed upon the newest and most approved plan. The alternate change from light to darkness is effected in a very simple and beautiful manner by the periodic revolution of the reflector-frame. This lighthouse measures 31 feet in diameter at the base; immediately under the cornice, it measures 17 feet in diameter over the walls; and its height above the medium level of the sea to the top of the light-room is only about 70 feet.

There was originally only one light-keeper at this station: but the new board have appointed four keepers, who take the duty two and two by turn. At Newcastle, on the opposite shore, distant about three miles, they have houses, &c. for the accommodation of their families; and here also the attending-boat is stationed, for the supply of stores, and for changing the keepers. Since this lighthouse has come under the management of the Corporation for improving the port of Dublin, it has undergone very considerable improvements; the situation of the light-keepers has also been rendered much more comfortable, and their condition more like that of the public service to which they belong.

The next lighthouse in point of importance, from its insular situation, and lately erected on the coast of Ireland by this corporation, is upon the Tusker rock, lying about six miles off the coast of Wexford. Although this rock is of considerable dimensions, presenting a surface of about 900 superficial feet, and is always about 12 feet above the highest tides, yet, from its position on the coast, it must hitherto have been extremely dangerous to the shipping of St. George's Channel. The erection of the Tusker lighthouse was brought more particularly under the notice of the public, from a melancholy accident which befel the artificers during the time that it was building, when the sea, after a continued storm, in the month of October, 1812, rose to such an unprecedented height, that the temporary wooden barrack in which the workmen were lodged on the rock was washed away, and fourteen of the workmen unfortunately drowned. The lighthouse is elevated 120 feet above the rock: it is built of granite, and in its form resembles the Eddystone lighthouse. From the height of the rock or base of the lighthouse above the rise of the tidal water, it is only necessary to have the entrance-door a few feet above the rock; and it is even found practicable to have a store-house upon it, separate from the lighthouse tower. The ascent to the different apartments of this lighthouse is by a stone stair, which winds round the inside walls of the building, through the several apartments, by which the accommodation for the light-keepers is considerably curtailed.

The Tusker lighthouse has a reflector-frame with three illuminated faces or sides, and is distinguished from the other lights on this coast, in being made to revolve by a train of machinery, shewing a bright light of the natural colour from two of its sides, and a red-coloured light from the third side. By a separate and distinct machine, two large alarm bells are rung in foggy weather. Every thing connected with this establishment seems to be upon the best construction, and agreeably to the latest plans of improvement.

There being as yet no proper harbour upon the coast immediately opposite to the lighthouse, the attending vessel has hitherto been stationed at Wexford, distant about 15 miles from the lighthouse. The establishment, however, of houses, &c. for the families of the light-keepers, is within view of the lighthouse on the nearest point of land. Connected with these, a signal-tower is erected, where a telescope is kept. Four light-keepers are attached to this establishment; and the business is conducted in a regular and systematic manner.

Of the other lighthouses on the coast of Ireland, it may be noticed, as of those on the shores of Great Britain, that they vary in their position and in their elevation above the sea, according as the respective positions happen to be situated upon lower or higher parts of the coast. Sometimes also they are erected upon the mainland, and in other cases upon detached islands. But those which have now been more particularly noticed, are erected upon insulated difficult situations, somewhat analogous to the Eddystone in England, and the Bell Rock in Scotland.

Revenue of Lighthouses.

The revenue for the erection and maintenance of sea-lights, in most of the countries of Europe, is taken from the common purse of the respective states. To give proper effect, however, to the marine, in this important department, it will in general be found better, perhaps, to place the lighthouses under the management of a special Board—a system which is found to answer extremely well in the British dominions. Here the lighthouse duties are exigible from all merchant or trading vessels, his Majesty's ships being always exempted, while foreign bottoms pay double the rates of British vessels. These duties are levied and collected at the different customhouses throughout the kingdom, and are afterwards remitted or paid over to the treasurer of the respective boards in England, Scotland, and Ireland.

The lighthouse duties are laid upon the register tonnage of each vessel passing or receiving benefit from the lights, as explained in the several acts of parliament. In England, and also, it is believed, in Ireland, the duty is exigible for each lighthouse separately; and the rate varies not indeed after a fixed rate, but it may be stated at from one farthing to three halfpence for each lighthouse. In Scotland, the mode of levying the lighthouse duty is different. Here, when vessels are *cleared out*, for the northern lighthouses, the sum of two pence per register ton is paid for the whole, including the Isle of Man. Regarding the lights of this island, however, there is an exception for vessels which do not pass any other of the northern lights; in this case, the sum or rate of one farthing per ton only is exigible for the whole three lighthouses on that island.

The funds of the several lighthouse boards vary considerably in their amount, according to the state and prosperity of the trade and commerce of the country. The accounts and state of the funds of the Scotch, or Northern Lighthouse Board, are annually laid before Parliament, and their amount may be stated at from £15,000 to £20,000 per annum. It is also provided for in the Scotch act, that the surplus duties shall be annually invested in the public funds; and, when a sufficient number of lighthouses shall have been erected for the protection of the coast, and a sum of money shall have been funded, the interest of which shall be sufficient for the maintenance of these lights, the duty shall then be modified, and ultimately cease.

Floating Lights.

It is believed that the floating light at the Nore was the first vessel moored for this purpose upon the coast of Great Britain, and that this description of light originated in, and is still entirely confined to the British dominions. The general description already given of the Bell Rock floating-light being applicable to all the floating-lights upon the coast, we shall here content ourselves with the notice there given of the subject. Some of these vessels are of a larger tonnage, while others are smaller, but they are in general moored in a similar manner; none of them have, however, as yet adopted the precise description of lantern which is screwed together longitudinally, and is made to traverse upon the mast by a tube passing directly through the lantern for the reception of the mast, instead of being attached to cumbrous yards; or if these are avoided, the light is still in part obscured by the mast on which the respective lantern traverses; whereas the lamps formed a luminous zone round each of the masts of the Bell Rock floating light, which, by this simple contrivance, was rendered visible in every direction.

Harbour Lights.

The harbour lights upon the shores of Great Britain, are to be considered less important than those properly termed *lights of the high seas*. But those lights of a more local nature are still, however, extremely useful to shipping, and are generally erected and maintained for the service and use of particular ports; but, on all mercantile coasts, these lights are so numerous that it would be hardly possible to give any satisfactory account of them in a work of this kind. We have, in Plate CCCXLVIII. given elevations of some of the principal foreign harbour lights, as those of Naples, Genoa, and Corunna; and also of Dublin in Ireland, Ramsgate in England, and the leading lights of the Frith of Tay in Scotland. The harbour lights on the continent, above alluded to, though situated either upon the moles or piers of particular ports, are also in some respects to be viewed as sea lights; and it is rather on account of the elegance of their form, or the celebrity of their position, that we have selected and given elevations of some of them, than from their particular utility as harbour lights.

Many local lights might be enumerated on the coast of Great Britain, such as those of the Liverpool and Bristol channels, and of the Friths of Clyde and Tay, &c. which are kept burning the whole night like sea-lights; but there is another description of harbour-lights, such as those erected upon the piers of Leith, Aberdeen, Ayr, Whitehaven, and harbours of the Isle of Man, and for Shields bar, at the entrance of the river Tyne, which are lighted only when there is a certain depth of tidal water in the respective harbours, as a direction for vessels when to enter. In Ireland, the same observations are applicable to the harbour-lights of Dublin, &c.

Distinguishing Lights.

The methods resorted to for distinguishing one light from another on the coast, in cases where the distance and bearings by the compass may be so trifling as to render some method of distinguishing them necessary, till of late, was only effected by showing double and single stationary lights, exhibited from separate lighthouse towers. This description of lighthouse is sufficiently characteristic; it is, however, not only expensive, but, from the frequent repetition, such lights have at length become so general, as to be no longer a distinguishing guide to the mariner. The next idea which suggested itself was the revolving light, exhibiting the alternate effect of light and darkness, by the periodical revolution of a *frame* or *chandelier* with reflectors, kept in motion by machinery. The revolving light has also been constructed as single and double; and even treble revolving lights, as at the Casket Rocks in the British Channel. But this mode, from the increasing number of lighthouses, it has also been found necessary to vary; and revolving lights are now distinguished from each other by shades of glass stained of a red colour, which are interposed between the eye of the spectator and the reflector. Upon the first suggestion of this plan, it was expected that a great *range of colours* might be made use of; but after many trials with glasses coloured red, and green, and blue, and also by means of coloured fluids introduced between plates of *white glass*, it has been found that *red* shades only were calculated to answer the purpose effectually of distinguishing and characterizing *sea lights*. To complete the lighting of the coasts of Great Britain and Ireland, however, many lighthouses must still be erected; and the distinguishing of the new lighthouses from those already in use becomes an object of the first consideration with persons engaged in these useful and important works.

Gas Lights.

In an age of improvement like the present, it is not improbable that, in some situations, it may be found practicable to introduce into our public light-houses the light of gas from pit-coal, or, as has been more lately proposed, with gas from oil. Propositions with regard to the gas of pit-coal was brought under the notice of the Lighthouse Board of Scotland about the year 1810, or soon after the gas lights became generally known, when it was proposed to alter the lighthouse of Inchkeith, situated in the Frith of Forth, from an oil to a gas light. But upon inquiring into the state of the expence of the apparatus, and other circumstances connected with this plan, it was found that the adoption of the proposed alteration would not be an object in point of economy. The gas light, in this instance, however, was disapproved of by the Scotch Board, chiefly from the apparent uncertainty which seemed to attend the regular and constant exhibition of these lights. The light of gas from pit-coal is said to have been introduced into the harbour lighthouse of Workington: but even in the present state of this beautiful discovery, it can hardly be considered so perfect as to be applied to the more important purposes of a public national lighthouse, for the direction of mariners on the high seas.

Our object in thus treating lighthouses, for the first time in any work of this kind, as a distinct article, has been principally to introduce a subject to the notice of our readers, which is of much importance to the affairs of nautical and commercial men, and one to which we trust the attention of men of science will be more and more directed.

It is therefore with much satisfaction that we are able to announce the expected appearance of a complete account of the Bell Rock, and the other northern lighthouses, by Mr. Stevenson, civil engineer.

LIGHTFOOT, John. See Botany.

LIGHTNING. See Electricity.

LILLE, or Lisle, a city of France, and formerly the capital of French Flanders, is situated in a marshy soil, and is watered by the river Doule, from which several branches traverse the city in different directions. Its Latin name was *Insula*, or *Insulæ*, *Isla*, *Castrum Illense*, and its Flemish name *Ryssel*, from its having been once surrounded by several marshes, which were drained by the industry of the inhabitants. The town is encircled with walls, and the citadel, constructed by Marshal Vauban, is inferior only to that of Turin. Lille is a very magnificent city. The Great Square, and the public buildings of Lille, have been much admired. There are more than 70 streets, some of which are very beautiful, 30 squares, and 24 canals. Before the Revolution, Lille contained many charitable foundations and establishments, few of which exist at the present moment. The principal gate, the theatre, the exchange, and the barracks, are now the chief objects of interest.

The principal manufactures of Lille are cloth, camlets, ratteens, silk and woollen stuffs, cotton goods, linen goods of all kinds, lace, tapestry, ribbands, carpets, hats, stockings, paper, soap, &c. Many of the merchants in Lille fit out vessels at Dunkirk, Ostend, and Calais; and in this way Lille has a direct trade with every part of Europe, with the French and Spanish colonies, and the Levant. In the vicinity of the town there are about 200 windmills, which are engaged in the manufacture of oil of Colzat, which is used for painting and for domestic purposes. Great quantities of freestone have been taken from below ground in the vicinity of the city, and in the excavations the inhabitants used to conceal their effects in time of war. Lille suffered severely in 1792, when it was besieged by the Austrians. Population 57,400. East Long. 3° 7′. North Lat. 50° 38′. See France.

LIMA, the capital of Peru, founded in 1535, is situated in 12° 2′ 34″ South Latitude, and 77° 7′ 30″ West Longitude, about two leagues from the sea-coast, and 30 from the Cordilleras. It stands in the midst of the spacious and delightful valley of Rimac, the name of an idol formerly worshipped there by the Peruvians, and supposed to have been corrupted by the Spanish pronunciation into Lima. A river of the same name runs close by the city on the north, watering the valley by numerous canals, and falling into the sea near Callao. Over this river, (which, though usually fordable, is often rendered very deep and rapid by torrents from the mountains) is built a handsome stone bridge, with a gate of beautiful architecture at one end, forming the principal entrance into the city. The form of the city is triangular, the longest side extending along the banks of the river above 3000 yards, and the greatest breadth from this base to the opposite angle amounting to above 2200. It is completely surrounded by an irregular brick wall, flanked with bastions, but without platforms or embrasures, and intended merely to sustain any sudden attack from the Indians. On the north bank of the river, opposite to the city, is a suburb, called St. Lazaro, of considerable extent, equalling the city itself in the regularity of its streets, and the beauty of its edifices. The city of Lima was in former times one of the handsomest and richest cities in the world; and was called by the Spaniards the queen of cities. The streets are regular, straight, and broad, some running in parallel directions, and crossed by others at right angles, so as to form squares of houses about 150 yards in front. They are well paved, and furnished with streams of water from the river, which are arched over, and rendered subservient to cleanliness and many other conveniences. The houses, though low, are generally commodious, and of a handsome appearance. They are constructed of wood on account of the frequent earthquakes, but in such a manner as to resemble stone buildings. The strong and thick timber work of the walls is covered on both sides with laths or reeds, plastered with mortar, white-washed within, and painted without in imitation of stone. The roofs are flat, and slightly covered with thin boards, upon which a little clay is spread, to protect them from the heat of the sun. On the east and west sides of the city, and within the walls, are several orchards and kitchen gardens; most of the principal houses also have gardens adjoining to them, refreshed with streams of water from the canals: and the environs of the place are ornamented with numerous alleys of lime trees, and clusters of country villas. The grand square in the middle of the city (of which each side is about 380 feet in length) is of great extent and beauty. In the centre is a large and magnificent fountain, ornamented by a bronze statue of Fame, from the trumpet of which, and the mouths of eight lions surrounding it, the water is ejected. The east side of the square is occupied by the cathedral and the archbishop's palace, both of which are lofty and magnificent buildings, partly constructed with stone. In the north side of the square is the viceroy's palace, in which are the courts of justice and several public offices; but the greater part of which was thrown down by an earthquake in 1687. On the west side is the town-house and city prison; and the south is occupied with private houses, which have fronts of stone, adorned with elegant porticos. The other principal buildings are the churches and chapels, which are partly built of stone, and decorated in the most splendid style with paintings and ornaments of the greatest value; the walls hung with velvet or tapestry, fringed with gold and silver; the altars covered with massive silver of various workmanship; the body of the church crowded with silver tables, candlesticks, and pedestals for the statues of angels; and the sacred vessels and vestments loaded with gold, diamonds, and precious stones, of the most dazzling brilliancy, and incalculable value. The convents also, which are extremely numerous, are generally large and commodious structures; and, by curious carved and painted wood work, are made to resemble the finest architecture. There are several literary colleges and institutions for religious instruction; and more than twelve charitable foundations and hospitals for different objects. The public offices for the administration of the government are, the audienza, in which the viceroy presides; the chamber of accounts, where all the collectors of the revenue pass their accounts; the royal treasury, to which all the finances of the province are remitted; the office of police, in which the alcaldes preside by rotation every month; the office of the corregidor, whose jurisdiction extends only over the Indians; the court of cognizance, for persons who die intestate, or without lawful heirs; and the tribunal of commerce, for deciding all commercial disputes. The ecclesiastical courts are, the cathedral chapter, the tribunal of inquisition, and the tribunal of the cruzada. There is also a university, provided with chairs for all the sciences, to which the professors are elected by suffrage, and in which many persons have distinguished themselves*; and a mint, with its proper officers, where the gold and silver coin is struck.

The inhabitants of Lima are composed of whites or Spaniards, Negroes, Indians, Mestizos, and other casts proceeding from the mixture of the first three. The amount of the whole population is estimated at 60,000; of which number about one sixth part are whites, and among them are many of the best Spanish families. The higher classes live in great splendour, and keep a great number of domestics and slaves. Their wealth arises from the extent of their estates, their civil or military appointments, or their gains by commerce, which is there accounted no derogation to the dignity of rank. On certain occasions and festivals, which are very numerous, particularly on new year's day, at the election of the alcaldes; on twelfth day, which is held as the anniversary of the founding of the city; and, above all, at the entrance of a new viceroy, the wealthier inhabitants vie with each other in displaying their magnificent equipages, dresses, and entertainments. The negroes, mulattoes, and their descendants, form the greater proportion of the inhabitants, carrying on most of the mechanical trades, and performing all domestic services. The Indians and Mestizos bear a small proportion to the last mentioned class, and to the extent of the city; and are chiefly employed in agriculture, pottery, and the conveyance of provisions. All classes are fond of fine clothing, and wear the richest stuffs of Europe as ordinary dresses. The women particularly carry their extravagance in this respect to an extraordinary degree. Their linens, even where not exposed to view, are covered with the finest lace; and their short petticoats are bordered with wide fringes of the same expensive article, through which are seen their garters, embroidered with gold or silver, and sometimes set with pearls. The sleeves of their shifts and jackets, which are of immense length and width, standing like wings on each shoulder, are loaded with rolls of lace, and slips of the finest cambric. Their feet are remarkably small, being confined by tight shoes from their infancy; and their buckles are studded either with diamonds, or with some very brilliant ornament, according to the wealth of the wearer. The heels of the shoes are sometimes made of whrougt silver; but on this article of dress ornaments are less liberally bestowed, that the appearance of the foot may not be enlarged. On public occasions and formal visits, they are still more richly adorned; and the ornaments of their hair, their ear-rings, necklaces, girdles, and bracelets, are of the most superb description and singular workmanship. A marriage shift frequently costs a thousand crowns; and a complete dress is often not less in value than thirty or forty thousand. Even the lower class of women, whose whole stock of apparel seldom consists of more than two shifts and a petticoat, wear their bracelets, rosaries, and golden images, to the value of 50 or 60 crowns, with the additional cost of nearly an equal sum for the benedictions of the priests upon these ornaments. The ladies of Lima are excessively fond also of perfumes and flowers; and every morning resort for the purchase of nosegays to the grand square, which has all the appearance of a spacious garden, from the quantity of beautiful plants with which it is filled. The women of Lima are said to have handsome persons, fair complexions, beautiful hair, and a pleasing lustre in their eyes; while their intellects are very acute, their behaviour easy, yet respectful, and their conversation inexpressibly interesting; and though chargeable with a considerable degree of haughtiness even towards their husbands, yet their address, affection, and general discretion, are seldom equalled in any other part of the world. The women of the lower classes, besides imitating their superiors in the love of dress, are remarkably cleanly, and keep their houses in the utmost neatness. They are naturally sprightly in their dispositions, and fond of music and dancing. The reigning passions in short of the fair sex in this city are, show, mirth, and festivity;

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* The Mercurio Peruano may be cited as affording a fair and favourable specimen of the literature of Lima. It is a periodical paper, begun in 1791, and intended to illustrate the topography and local history of Peru.

and the inhabitants, in general, are distinguished by their vivacity, intelligence, and agreeable manners. The nobility are full of courtesy and complaisance; and particularly to strangers they testify the greatest probity and kindness. The native Indians, though proud and obstinate under haughty treatment, are capable of being easily managed by affability and gentleness. The mulattoe race are the most turbulent, uncivilized, and immoral, but not more so than might be expected in so populous a city.

Lima, besides being the capital of Peru, is the general emporium of the kingdom, and the common factory for commerce of every kind. On the arrival of the fleet with European commodities at Callao or at Paita, the merchants of Lima forward to their correspondents in the other cities, such articles as they had received commissions to purchase, and reserve the rest in warehouses, to be disposed of on their own account to traders who resort to the place, or to be sent to their factors in the inland provinces. The produce of these sales in the interior is remitted in bars of silver, upon which also a great profit is made at the mint. Besides this foreign trade, Lima is the medium of all the traffic between the different provinces of North and South America, receiving from the Havannah through Mexico, great quantities of snuff and other perfumes; from the ports of New Spain, naphtha, tar, iron, and indigo; from Terra Firma, pearls and tobacco; from Guayaquil, cacao and timber, which last article, brought by the ship-masters on their own account, is deposited in store-houses at Callao till an opportunity of sale occurs; from the coasts of Nasca and Pisco, wine, brandy, raisins, olives, and oil; from Chili, wheat, flour, lard, leather, cordage, wines, dried fruits, and some gold; from Coquimbo, copper and tin bars; from Caxamarca and Chacapoyas, cotton, canvas, and other similar stuffs; from the adjoining districts, cordovan leather and soap; from the southern provinces, Vicuna wool, and certain very fine stuffs; from Paraguay, the cattle of that district, of which there is a vast consumption in Lima, and the other large towns. Many of these articles are laid up in warehouses at Callao, where there is a fair every Monday, frequented by dealers from all quarters. The inhabitants of Lima have a peculiar aptitude for mercantile pursuits; and the city is considered as a perfect academy for acquiring the art of trade. But while they exercise every species of precaution and finesse in buying and selling, they are equally distinguished by the punctuality and probity with which they fulfil their contracts. Notwithstanding, however, this extensive commerce of the place, and peculiar talent of the people for traffic, there are not many houses or individuals who possess great wealth, which is doubtless owing to the number of competitors in the field, and to the enormous expense of maintaining and establishing their families. The greatest annual income in Lima does not exceed, according to M. Humboldt, 130,000 francs, which is not the tenth part of several in Mexico; and the generality of rich persons have not more than 30 or 60,000 francs per annum. At the same time, there is none of that extreme poverty in Lima which is witnessed in Mexico; and many mulattoes and free negroes possess property to the amount of 10,000 or 15,000 francs, while the poorest tradesman earns not less than two dollars a day. The trade of Lima also has greatly decayed, in consequence chiefly of the growing prosperity of Buenos Ayres, which is more conveniently situated for European commerce, and to which the produce of the mines of Potosi and La Plata is conveyed by a more speedy and secure route than that of Lima. European goods also have been imported far beyond the demand; and the consequent loss of mercantile capital had produced a scarcity of money, which interrupted the working of the mines. The annual importations of Lima are estimated by M. Humboldt at the value of five millions of piastres; and its exportations, including precious metals, at seven millions. At the mint there was coined, between the years 1797 and 1801, gold and silver to the amount of 26,032,653 piastres, or 5,466,000*l*. For farther particulars of the commerce of Lima, see PERU.

The climate of Lima is much milder than might be anticipated from its degree of latitude; and all the seasons are extremely temperate. The thermometer at noon, is never observed in winter below 60° Fahrenheit, and seldom rises in summer above 85°. The hottest day ever known in the city, was in February, 1791, when the thermometer rose to 96°. Spring commences about the end of November, when the dense fogs of winter subside, and the rays of the sun break through the atmosphere. The heat of summer is moderated by the south winds, which blow during the season with great regularity, and without violence. The autumn may be placed in the months of May and June, after which the winds from the south become stronger and colder, rendering it necessary to use warmer stuffs in clothing. The density of the fog during this season completely obscures the sun and stars, especially in the immediate vicinity of the city of Lima; but the gentle dews which prevail at this period of the year, and which afford the only moisture known in the country, clothe the earth with verdure and flowers, and render the country the most attractive residence to the inhabitants. Tempests of wind, or thunder and lightning, are as rare, or rather as completely unknown at Lima as falls of rain, (though sufficiently frequent and furious among the mountains at 30 leagues distance,) nor are the winds ever known to occasion any damage by their violence; but the slightest change to the north, which takes place at the beginning of winter, occasions violent headachs, and other uneasy sensations to the inhabitants. During summer, the principal inconvenience arises from the musquitoes, which are extremely troublesome. But the most grievous pest of the country at that season, is the multitude of fleas and bugs, which swarm among the dust of the dung of the mules, with which the streets and the flat roofs of the houses are covered, and which swarm over the whole of the apartments, in spite of all possible care to exclude their visits.

The adjoining country is remarkably fertile, producing all kinds of grain and fruits in the greatest abundance; and the fields are regularly watered by a complete arrangement of canals and trenches, originally executed by the Incas, and kept in due repair by the Spanish authorities. As every family of any importance keeps a calash, or single horse carriage, and all the wealthier people have their coaches, the number of horses, particularly of mules, is very great; and, for the subsistence of these animals, almost all the fields around the city are sown with clover, except where the ground is occupied with gardens and vineyards. Next to these are the plantations of sugar cane, and the groves of olive trees, both of which are very extensive, and cultivated by Negro slaves with the hoe. The soil is of a stony and sandy quality, full of smooth flints and pebbles; but at the same time full of springs, which are found every where at the depth of four or five feet. The provisions with which the city is supplied from its fertile country and favourable climate, are equally abundant and excellent. Of animal food, mutton is most commonly used; and pork, which was originally introduced when the country afforded no oil, is still very plentiful; but beef, though also good, is little eaten by the Europeans. Fish is daily brought in great variety from the neighbouring ports, and particularly anchovies, which frequent the coast in immense shoals.

The diseases most common in Lima, are fevers, pleurisies, and constipations, which are continually raging, and a very afflicting species of convulsions, which, however, appear to be an attendant on the crisis of other distempers, rather than a peculiar or distinct disease. The women of Lima are subject to a very painful and lingering disorder, namely, a cancer in the matrix, which is remarkably contagious, and almost incurable.

But the most direful evil to which this capital and the adjoining country are subject, is that of earthquakes, which are so frequent, that Ulloa enumerates more than six, which happened in the space of five months during his residence in Lima. The inhabitants, amidst all their characteristic gaiety, (which seems very irreconcileable with such impending dangers,) live in daily apprehension of being buried under the ruins of their houses; and on the first symptoms of an approaching shock, the whole population rush into the streets in the utmost terror. Nor is their alarm without foundation, when it is considered how frequently these concussions have laid their city in ruins. Since the year 1582, more than sixteen earthquakes have occurred, of such violence, as to occasion more or less damage to the buildings, and destruction of lives; but the most fatal took place in the years 1687 and 1746, both of which overturned almost the whole houses of the city, and swallowed up the port of Callao, with the greater part of its inhabitants. During the last particularly, 200 concussions were counted during the first 24 hours, and 450 were observed in the space of four months. But still the inhabitants retain their passion for lofty buildings, though they have an instance in their vicinity, of the benefit which might attend a different mode of building. In the valley of Guacachipa, about three leagues north-east from Lima, are the ruins of a large town, of which no tradition remains, but which is called Old Caxamarca. These walls, though built only of mud on the surface of the earth, without any foundations, have sustained no injury from the numerous earthquakes which have laid the Spanish cities in ruins.

The province of Lima, which forms one of the five districts, of which the audience of Lima, or viceroyalty of Peru, is composed, extends along the coast of the Pacific Ocean; and is subdivided into several subordinate districts, namely Conchucos, about 156 miles in length, and 60 in breadth, in which some mines of very pure gold, silver, and sulphur, are found, and various kinds of fruits, as well as luxuriant crops of grain, are produced; but which furnishes wealth and commerce to its inhabitants, chiefly by the numerous flocks with which it is covered. Santa, about 120 miles in length, and 36 in breadth, abounding in mines containing loadstones, and possessed of several commodious harbours, but trafficking principally in wool, cotton, hogs-lard, sugar, and distilled liquors. Caxatamba, 102 miles long, and 96 broad, in which are several mines of copperas, alum, and silver, and no want of excellent fruits, but where the inhabitants place their wealth in flocks and herds, and confine their trade to woollen stuffs, which they occasionally dye with the cochineal produced in the district. Guanuco, where the climate is peculiarly mild and salubrious, and the soil highly productive, particularly in cotton and cocoa. Tarma, where the climate is colder than in any other district of Lima, and where (though some silver mines were found) the inhabitants trade chiefly in the wool of their numerous flocks and manufactured stuffs of different kinds. Chancay, or Annedo, which abounds in salt pits, and where the inhabitants raise immense quantities of maize, with which they fatten hogs and pigeons in great numbers for the market of Lima. It is in this district that the land is rendered extremely fertile, by being manured with the dung of a bird named huanaco, which frequents the small islands on the coast. See Helm's *Travels to Lima;* Ulloa's *Voyage to South America*, v. ii.; and the article CALLAO. (*q*)

LIMBOURG, a town of the Netherlands, is situated between two branches of the river Weze or Veze. It was formerly well fortified with a castle built on a rock, and had a fine stone bridge, a collegiate church, and three convents. There are several quarries of different kinds of marble in the neighbourhood, and the country around is very agreeable and romantic. There is a considerable manufactory of woollen cloth here, and cheese is made in great quantities in the neighbourhood. Population 1484. East Long. 23° 30′. North Lat. 50° 36′.

LIME. See AGRICULTURE, CHEMISTRY, MATERIA MEDICA, and MINERALOGY.

LIME-KILNS, are buildings in which limestone is converted into lime by means of heat.

LIMERICK, called *Lumniach* by the Irish, is the name of a city of Ireland, and capital of the county of the same name. It was formerly the second city in Ireland, but the rapid increase of Cork soon deprived it of this eminence. It is strongly situated upon the river Shannon, about 60 miles from its mouth, upon an island, on which the town is partly built. The town is about three miles in circumference, and is divided into the Irish and the English towns. The English town, which is the most ancient, is situated in King's Island, formed by the Shannon; and was esteemed the strongest place in Ireland when it was fortified. It was, however, dismantled about 50 years ago, and since that period it has been greatly agumented by several handsome streets and convenient quays. The New Port, which communicates with the old city by a bridge, is called Newtown Pery, after the Pery family, and belongs to the county of Limerick, by whom that family is now represented. Its buildings, which are of brick, are large and uniform, and the streets are wide and handsome.

The principal public buildings of Limerick are the Custom House and the Cathedral, and the Bishop's Palace. The Custom House is a plain structure. The Cathedral is an ancient pile, and the Palace of the Bishop is a neat modern house at the west end of the city. Limerick has also a good public library, a theatre, and many charitable establishments. It contains four Protestant churches, one for the Methodists, one for the Presbyterians, one for the Quakers, and eight chapels for the Roman Catholics.

Limerick carries on a very extensive trade; and being adjacent to some of the richest grazing and corn districts of Ireland, it enjoys a larger share of the corn trade than any other port. The canal connecting the Shannon with the Liffey will no doubt add greatly to its commerce. The quantity of corn exported from Limerick in 1810-11 was,

Wheat, ...	50,998 bolls
Oats, ...	173,793 ditto
Barley, ...	74,680 ditto.

Limerick is likewise a market for American produce. Yarn is also exported, and coals are received in return. The other exports are beef, pork, butter, hides, and rape seed; and the imports are, rum, sugar, timber, tobacco, wine, bark, and salt. The manufacture of linen and woollen goods, and paper, is carried on to a considerable extent. The customs and excise amount annually to 32,000*l.*

Limerick is governed by a mayor, two sheriffs, a recorder, a town-clerk, aldermen, and burgesses. It sends two members to the united parliament. The corporation possesses the power of making an indefinite number of freemen. The neighbourhood of Limerick is covered with neat villas, the residence of its wealthy and respectable merchants. Mr. Wakefield says, that the population of Limerick has been estimated at 60,000, of whom not above 5,000 are Protestants. North Lat. 52° 41′ 30″, West Long. 8° 31′.

LIMERICK, a county of Ireland, in the province of Munster, is bounded on the north by the counties of Clare and Tipperary, from the former of which it is separated by the Shannon; on the west, by the county of Kerry; on the south, by Cork; and on the east, by Tipperary. It has the form of a parallelogram, and is 51 English miles long from east to west, and 32 broad from north to south. It contains about 1045 English square miles.

Limerick is by no means a mountainous county, though it is variegated by several small hills. On its south-eastern coast, however, it is bounded by a lofty ridge of mountains, called the Galtees, which stretches into Tipperary, and its western limits are marked by a grand amphitheatre of low but steep mountains, which extend in a wide curve from Loghill to Drumcolloher.

The soil of Limerick is good for tillage, and productive of grass. The great fertility of the ground called the Corechs or Corcesses, which are from two to three miles broad, is occasioned by the rich manure which the Shannon deposits. The rich land reaches from Charleville, at the foot of the mountains, to Tipperary by Kilfenning, a distance of 25 miles, and from Arpetuch to within four miles of Limerick, a distance of 16 miles. There is good land about Bruff, Kilmalloch, and Hospital, and Mr. Young estimates the amount of excellent land at 100,000 acres, which is chiefly under bullocks. Mr. Young considered the land near Castle Oliver as the richest he ever knew, and as applicable to every purpose. Notwithstanding the richness and the fertility of the soil, the county of Limerick has a desolate appearance. The quantity of wood is small, and much remains to be done in cleaning and enclosing the ground. A great many of the best long horned cattle are fattened here, and though Limerick is by no means a breeding county, yet very excellent sheep are fed in it. Timber is in request in this county chiefly for building cabins, and its price has increased in a much greater proportion than the rent of land. American staves are actually sold at Limerick, and cost far less than timber produced in the county. Hemp was formerly cultivated to a very considerable extent, but it has been given up. In 1808, 39 acres 3 roods were planted with it.

More than 100 years ago, a colony of Palatines were settled in the county of Limerick, by Lord Southwell. They occupy three villages, and amount in all to about 70 families. They are very industrious, and are better fed, clothed, and lodged, than the Irish peasants. They have in general leases for three lives, or 31 years. They are not cottars for any farmer; and are paid in money whenever they are employed. Another colony, taken from the first, was planted by Silver Oliver, Esq. on his own estate. They consisted in all of 66 families, amounting to nearly 700 Protestants. The Limerick merchants give the Palatines one penny per stone more than the market price for their corn.

The principal proprietors in Kilkenny, are Lord Courtenay, who possesses 42,000 acres, the annual rent of which was 38,000*l.* in 1811; Lord Limerick, who, independently of his property in the city of Limerick, has an annual rent of 6000*l.*; Lord Clare, 9000*l.*; Lord Southwell, 10,000*l.*; Lord Charleville, 5000*l.*; Lord Sandwich, 15,000*l.*; Count de Sales, 15,000*l.*; Mr. Oliver, 9000*l.*; Lord Massie, 7000*l.*; Lord Egremont, 3000*l.*; Lord Adair, 6000*l.*; Marquis of Headford, 4000*l.*; Sir Edward Harrup, 5000*l.*; Mr. Pigott, 10,000*l.*; Lord Kenmare, 3,800 acres, &c. The leases are in general for 31 years and three lives. The price of land near Castle Oliver, though in the midst of mountains, is four guineas per acre.

The following were the prices of labour and provisions in 1811: Wages of a man per day, 1s. 2½d.; wages of a woman, 9d,; grazing a cow per week, 7s. 7d.; grazing a horse, 7s. 7d.; Kilkenny coal per cwt. 2s.; potatoes per lb. 3½d.; fresh butter per lb. 1s. 4½d.; hay per ton, 2*l.* 17s.; mutton per lb. 6¼d.; beef per lb. 6d.; eggs per score, 1s. 3d.; cheese per lb. 11d.; fowls per couple, 1s. 8d.; turkeys each, 3s. 1¾d.; geese 3s.

The river Maig, which crosses the county, and falls into the Shannon, rises in the Galtees mountains; and the Feale and the Gale, which run northward through Kerry; and the Black Water, which takes an opposite course through the county of Cork, have their source in the western hills.

The principal places in the county are Limerick the capital, Askeyton, Kilmalloch, Adair, and Castle Connel. Limerick has already been described in the preceding article. Askeyton is a decayed village, situated on the small river Diel, near its junction with the Shannon. It was formerly a market town of consequence, and encircled with walls. It is famous for a castle, built by one of the earls of Desmond, and the ruins of a Franciscan monastery, founded in 1420. The castle was built on an island formed by the river Diel, but only one side of it now remains. The hall called the Desmond Hall, rests on arches still entire. The ruins of the abbey stand on the other side of the river, at the distance of a few hundred yards. The cloisters, which are very entire, are built of sculptured marble, and would have been perfect, had not two of the pillars been secretly carried away in 1784. At the north-east end of the abbey is a vaulted burying-place. Adair, now a poor village, stands on the Maig, which is crossed by an old bridge of nine arches, and is navigable for large boats. The ruins of an old castle overhang the river, and the town contains the remains of several religious houses. Kilmalloch, formerly one of the best built inland towns of Ireland, is now a miserable village. It still exhibits the ruins of many large stone houses, of churches, monasteries, gates, and walls. Castle Connel is a beautiful village, so called from its old castle, situated upon a rock. It is frequented on account of its medicinal springs, and consists chiefly of lodging houses, almost all of which are neat and white washed.

The county of Limerick sends two members to parliament. The Earl of Clare recommends one member. There are 3000 freeholders in the county. The county is divided into 10 baronies, and 125 parishes, which by the Union form 60 benefices, of which only 33 had parish churches when Dr. Beaufort wrote.

The number of houses in the county of Limerick is calculated at 28,748, and the population at 170,000, by far the greater part of which are Catholics. The climate of Limerick seems to be wet. In 1810 there were 217 days of rain, and in 1811, 246. During the two years preceding 1811, the barometer ranged between 28,5930.5. The greatest height of the thermometer in summer, in the shade, is 72°. See Dr. Beaufort's *Memoir of a Map of Ireland;* Arthur Young's *Tour in Ireland;* and Wakefield's *Statistical Account of Ireland passim.*

LIMMA, in music, is the name of an interval, of the class of *semitones*. When first the term was introduced by Pythagoras, it was intended to express the remainder or remnant, (as Euclid terms it,) after two major tones are taken from a diatessaron; but the more modern writers have used it to express a variety of other intervals, some of which even belong to the class of *tones*, all which it is proper the musical calculator should be acquainted with, viz.

LIMMA, *Comma-deficient*, (L — C, or L'), has the ratio $\frac{19683}{20480}$ or $\frac{3^9}{2^{12}.5}$ = 35Σ + f + 3m in Farey's notation; its common logarithm is .9827613,4018; its Euler's or binary log. .05.7267; its major comma log. 3.19528; and its schisma log. 35.173248. The following equations will shew some others of its relations to the other intervals. In Plate XXX. Vol. III. and in the *Phil. Mag.* vol. xlix. p. 360, viz. it is = D + E, B + 𝔣𝔠, 𝒻 + 𝔈, π + 2 𝔈, or r + 3 c; also = ℑ — Σ, 𝔖 — 𝔡, I — 𝔡, 2 — 2 c, 𝔖 — 3 c, or S — 2 c. It is also = Σ + r + ∫, or T — 2 c — S; = — 2 T + 2 t + S, — 4 3ds — 3 IIIds + 5 4ths, or III — 9 V + 5 VIIIths; by either of which last this interval may be correctly tuned upon a Listonian organ; whereas its place above C will be found to be D''♭. See our articles ENHARMONIC *Organ* and INTERVAL. (ϱ)

LIMMA, *Diaschisma-defective*, (L — 𝔡) has the ratio $\frac{129,140,163}{134,217,728}$, or $\frac{3^{17}}{2^{27}}$, = 34 Σ + f + 3m; its common log. is .9832514,4730, = .055644 × VIII, = 3.10445 × c, = 34.173248 × Σ. It is = ∫ + r. β + χ, φ + 2 𝔡, or D + 2𝔈; also = 𝒮 — 2 Σ, P — 2 𝔡, or 3 D — 2 𝔣𝔠; and = 𝒻 + 𝔈 — Σ, — 4 T + 3 t + 3 S, — 7 3ds — 7 IIIds + 10 4ths, or — 17 V + 10 VIII; by either of which last it may be tuned, and will be found equal CE'4♭3 of Liston's scale, as extended by Mr. Farey in the *Phil. Mag.* vol. xlix. p. 443. (ϱ)

LIMMA, *Double*, (2 L), has the ratio $\frac{59049}{65536}$, or $\frac{3^{10}}{2^{16}}$ = 92Σ + 2f + 8m; its log. = .9547326,1658; 2 L = 𝔛 + γ; = T — 𝔡, II — 𝔡, t — Σ, or VIII — 5 T; = 3 — 𝔖 — Σ; = — 4 Vths + 6 4ths, or — 10 III + 6 VIII: by which last it appears to be tuned as E''♭♭ of Liston's extended scale. It was denominated by M. Bemetzrieder a diminished *third*. (ϱ)

LIMMA, *Grave*, of Liston's *Essay*, has the ratio $\frac{24}{25}$ = 36Σ + f + 3m. It is CC'♯ on his organ, and occurs 33 other times between its 59 notes. It is the SEMITONE *Minor*, which see. (ϱ)

LIMMA, *Greater Enharmonic*, or greater of the *mean tone* system, (L), is equal S + ¼ c, or S — ¾ c; it is = 59.7519656 Σ + f + 5m, and its log. = .9706225,1843. See MEAN TONE *System*, and Vol. VII. p. 739. (ϱ)

LIMMA, *Greatest*, of Chambers, has the ratio $\frac{1024}{1125}$, = 83 Σ + 2 f + 7 m; and is the *Minimum* TONE, which see. (ϱ)

LIMMA, *Lesser Enharmonic*, or lesser of the *mean tone* system, (l), is equal 𝒮 + ¼ c, or 𝔖 — ¾ c; it is = 38.7519656Σ + f + 3m, and its log. is .9809224,7507. It is the flat and the sharp of the MEAN TONE *System*, which see, as also Vol. VII. p. 739. (ϱ)

LIMMA, *Major*, (or greater) of Euler, has the ratio $\frac{25}{27}$, = 68 Σ + f + 6 m, and is the SEMITONE *Maximum*, which see. (ϱ)

LIMMA, *Major*, of Maxwell, has the ratio $\frac{128}{135}$, = 47 Σ + f + 4 m, and is the *Medius* SEMITONE, which see. (ϱ)

LIMMA, *Major*, of regularly tempered scales, (L). See a general theorem for the values of these, in Vol. VII. p. 739. (ϱ)

LIMMA, *Minor*, (or lesser) of Euler, has the ratio $\frac{128}{135}$, = 47 Σ + f + 4 m; the SEMITONE *Medius*. (ϱ)

LIMMA, *Minor*, of Maxwell, has the ratio $\frac{24}{25}$, = 36 Σ + f + 4 m; and is the *Minor* SEMITONE, which see. (ϱ)

LIMMA, *Minor*, of regularly tempered scales, (l). See theorem in Vol. VII. p. 739. (ϱ)

LIMMA of *Boethius*, (greater,) Glareanus, Kircher, &c. has the ratio $\frac{2165}{2304}$, = 54.951163 Σ + f + 5 m, the common logarithm of which is .9729754,2594. It exceeds five major commas by only .100824 Σ. (ϱ)

LIMMA of *Boethius*, (lesser), according to Glareanus is $\frac{4}{9}$ths of the major tone, = 46.205593 Σ + f + 4 m, its common logarithm is .9772655,4558. (ϱ)

LIMMA of *Philolaus*, is stated to have been $\frac{13}{27}$ths of the major tone, = 50.0711519 Σ + f + 4 m, the common logarithm of which is .9753710,0771. (ϱ)

LIMMA of *Pythagoras*, (greater), has the ratio $\frac{15}{16}$, = 57 Σ + f + 5 m; and is the SEMITONE *Major*, which see. (ϱ)

LIMMA (L) of *Pythagoras*, (lesser), Maxwell, Overend, Callcott, Liston, &c. or simply *the* LIMMA of the nomenclature adopted in our work. See Plate XXX. Vol. III. Its ratio is $\frac{243}{256}$, or $\frac{3^5}{2^8}$, = 46 Σ + f + 4 m. Its common log. is .9773663,0828; and its other logs. are, .075189 × VIII, 4.19528 × c, 46.181113 × Σ. Its elements of perfect tune (as they were first stated in *Phil. Mag.* vol. xxxvii. p. 274) are, = 𝒻 + 2 𝔈 + Σ; its diatonic elements, = — T + t + S; its chromatic elements, (*Phil. Mag.* vol. xxxix. p. 414,) = S — 𝔖 + ℑ: and in concordant or tunable intervals, it is 3 4ths — 2 IIIds — 2 3ds, 3 4ths — 2 Vths, or 3 VIIIths — 5 Vths; which last is the mode of tuning this interval above C in Mr. Liston's extended scale. viz. $D^{\backslash}\flat$.. (See INTERVAL.) Besides which, it occurs 27 times in the various intervals between the 59 notes of the scale of Mr. Liston's ENHARMONIC *Organ*, which see.

The following equations exhibit the relations of the limma with all the other intervals, viz.

$L = f + 2T$
$L = f + {}^{2}3$
$L = r + 4c$
$5L = r + 4S$
$3L = r + 2S$
$L = \chi + \Delta$
$L = \mathfrak{fc} + 2E$
$2L = \gamma + \maltese$
$L = 2\mathfrak{C} + \delta$
$L = \pi + \beta$
$L = 2\Sigma + \mathfrak{fc}$
$L = E + \mathscr{f}$
$L = \Delta + \chi$
$L = 2\mathscr{f} + \mathfrak{fc}$
$L = 2\mathscr{S} - \delta$
$L = \mathfrak{S} - \Sigma$
$L = S - c$
$L = 2S - S$
$L = P - \mathfrak{d}$
$L = \S - 2c$
$2L = t - \Sigma$
$L = t -$
$2L = T - \mathfrak{d}$
$L = T - P$
$L = 3 - T$
$5L = 4 - 2\mathfrak{d}$
$3L = 4 - 2P$
$L = 4 - 2T$
$L = {}_{3}4 - 2V$
$L = {}_{5}4 - 2VIII$
$7L = V - 3\mathfrak{d}$
$4L = V - 3P$

$L = \mathfrak{C} + \mathscr{S}$
$L = \varphi + 3\mathfrak{d}$
$4L = \varphi + 3P$
$7L = \varphi + 3T$
$17L = 2\varphi + {}^{3}4$
$8L = \varphi + V$
$34L = 4\varphi + {}^{3}7$
$41L = 5\varphi + {}^{3}VIII$
$L = D + \int$
$L = V - 3T$
$10L = 7 - 4\mathfrak{d}$
$6L = 7 - 4P$
$2L = 7 - 4T$
$2L = {}_{3}7 - 4V$
$2L = {}_{5}7 - 4VIII$
$12L = VIII - 5\mathfrak{d}$
$7L = VIII - 5P$
$2L = VIII - 5T$
$L = 3VIII - 5V$
$L = \mathscr{f} + 2\Sigma + 2m$
$L = \mathscr{f} + 3\chi + d$
$L = \mathscr{f} + \pi + R$
$5L = 3\mathfrak{S} + 4E + R$
$L = 3\pi + F - f$
$L = \mathfrak{S} + \mathfrak{fc} - \mathscr{f}c$
$L = E + \mathscr{f} - \int$
$L = VI + 5 - 2V$
$L = 8 + \mathscr{S} - VII$
$L = III - T - \mathfrak{S}$
$L = IV - III - P$
$L = 6 - 5 - P$
$L = VII - 7 - \Sigma$

This interval has been called the ancient hemitone of Pythagoras and Aristoxenus, the hemitonum (or semitone) of Boethius and Sauveur, the remnent of Euclid, the residual of Dr. Boyce, the comma-deficient minor *second*, the diminished second of Bemetzrieder, the chromatic semitone of the Abbe Feyton, the deficient major semitone of Chambers, &c. (ϱ)

LIMMA, *Redundant*, of Liston's *Essay*, has the ratio $\frac{1024}{1125}$, $= 3\Sigma + 2f + 7m$; and is the *Minimum* TONE, which see. (ϱ)

LIMMA, *Triple*, (3 L) has the ratio $\frac{14,348,907}{16,777,216}$, or $\frac{3^{15}}{2^{24}}$, $= 138\Sigma + 3f + 12m$; its log. $= .9320989.2486$: It is equal $T + \int + r$, or 9 VIII — 15 V; and is $F^{\backslash 3}\flat\flat$ of Liston's extended Scale. See INTERVAL. (ϱ)

LIMMA *Variable*. In the 3d Prop. of Sect. V. of Dr. Smith's *Harmonics*, he has given a table of the synchronous variations, in any manner, of the two mean limmas, and five mean tones, of which he there assumes every tempered octave to be composed. (ϱ)

LIMMAT. See SWITZERLAND.

LINCOLN, a city of England, and the county-town of Lincolnshire, is 131 miles to the north of London. It is situated on the side and top of a high hill, from which there is a steep descent to the south, where the Witham flows, divided into three small channels. It is an ancient ill-built city, which has fallen off much from its former splendour and celebrity; it consists chiefly of two long streets and several smaller ones. There are two suburbs, one part of which extends from the foot of the hill to the south, the other lies on the north side of the city, and is called Newport. Till within these few years, there were very few improvements in Lincoln; but very lately, some of the footpaths have been paved, a market-place has been erected, and the town has been lighted; a new road has also been made. There are eleven parish churches, besides the cathedral; the assize-hall and the town-hall are the other public buildings worthy of notice. The cathedral, which is very large, is much and justly admired for its inside architecture, which is in the richest and lightest Gothic style. Being situated on the top of a hill, and the country being very flat to the south-east and south-west, it may be seen at the distance of 20 miles. Its western front is most remarkable for the beauty and magnificence of its architecture. The church is ornamented with three towers; and, till the year 1808, each of these was surmounted with a central spire, the height of which was 101 feet. The two western towers are 180 feet high; they are all highly decorated. The great tower in the middle of the church is 300 feet high. Besides the western front already mentioned, what is called the great marigold window, and the great bell, particularly deserve notice. The first foundations of this cathedral were laid in 1086; it was rebuilt in 1283. The parish churches of Lincoln are very mean. The county jail is a strong and commodious structure, on Mr. Howard's plan. Lincoln is a county of itself, with four townships in the neighbourhood subject to it, called the Liberty of Lincoln—a privilege granted by George I. and unequalled by that of any city in the kingdom. It is governed by a corporation, consisting of a mayor, twelve aldermen, two sheriffs, twenty-eight common-council men, and four chamberlains, with several inferior officers. It returns two members to Parliament, the right of election being vested in the citizens and freemen, amounting to about 1200.

The trade of Lincoln depends principally on the Witham. As this river has a navigable communication with the Trent, and of itself navigable to Boston, Lincoln has a great trade on it in corn and wool. Large quantities of these are sent into Yorkshire, from which are brought back coals, &c. There is a small manufacture for camlets in this city.

In 1801, Lincoln contained 1574 houses, and 7398 inhabitants. In 1811, it contained 1868 houses and 8861 inhabitants.

See *Beauties of England and Wales*, vol. ix.; and Young's *Agricultural Report of Lincolnshire*. (W. S.)

LINCOLNSHIRE, a maritime county on the east coast of England, is bounded on the north by Yorkshire, from which it is in part divided by the river Humber; on the east by the German Ocean, by the arm of the sea called the Wash, and by Norfolk; on the west by Nottinghamshire and Leicestershire; and on the south by the counties of Rutland, Northampton, and Cambridge. It is of an oblong form, presenting an extended coast, in the form of a bow, to the German Ocean. In respect to size, it is the third county in the kingdom. Its length is about 70 miles; its greatest breadth 45; and its circumference 260. Its area comprises 2787 square miles, or, according to other authorities, 2814. The number of its acres is estimated by some at 1,800,880, and by others at 1,848,320; and, according to another calculation, at 1,893,100: of this area, it is calculated that there are about 473,000 acres of enclosed, marsh, and fen lands; 200,000 of commons, wastes, and unembanked salt marshes; 268,000 of common fields, 25,000 of woodlands, and 927,120 of enclosed upland. Such is the calculation of Mr. Stone, in his Agricultural Report of this county. Mr. A. Young divides its area differently. According to him, the Wolds contain 234,880 acres; the heath 178,400; the lowland 776,960; and miscellaneous 718,880.

Lincolnshire is divided into three districts, called Holland, Kesteven, and Lindsey. Holland is subdivided into three hundreds, and contains 5 market towns and 36 villages. Kesteven is subdivided into nine hundreds and three sokes, and contains 7 market towns and 190 villages; and Lindsey is subdivided into fifteen hundreds and two sokes, and contains 1 city, 19 market towns, and 431 villages. This last division is by much the largest, occupying nearly one half of the county. extending from the sea on the east, to Nottinghamshire on the west, and from the Witham to the Humber. In this space are comprised upwards of 1,000,000 acres. Kesteven is bounded on the north and north-east by the Witham, which separates it from Lindsey; on the east by the division of Holland; on the south by the river Welland, which separates it from Northamptonshire; and on the west by Nottinghamshire, Leicestershire, and Rutlandshire. Holland forms the south-east part of the county. It is bounded on the west by Kesteven; on the east by the sea; on the south by Cambridgeshire and Northamptonshire; and by Lindsey on the north. This division is subdivided into Upper and Lower Holland. The principal towns are, Lincoln, a city, and the county town, Boston, Stamford, Spalding, Louth, Barton, Grimsby, Gainsborough, Horncastle, and Spilsby. It contains 630 parishes; is in the midland circuit, in the province of Canterbury, and diocese of Lincoln, and returns 12 members to parliament; two for the county, two for Lincoln, two for Grimsby, two for Grantham, two for Stamford, and two for Boston.

There are three grand natural divisions of this county; the wolds, heaths, and fens. The wolds extend from Spilsby, for about 40 miles, in a direction nearly north-east, to the vicinity of the Humber at Barton; their average breadth is about eight miles. The heaths, to the north and south of Lincoln, constitute a tract of high country, sloping in general sharply to the west. Beneath the line of the wolds, and parallel with the coast, lies an extensive tract of land, stretching from Barton to Wainfleet, in a direction north-west and south-east. Its breadth varies from eight to ten miles. This is distinguished from the fens properly so called, and is denominated the Marsh. It is protected from the encroachments of the sea by embankment. Part of the fens are in the district of Kesteven, but by far the greater part are in the district of Holland. These form one of the most striking features of the county; they consist of lands which, at some remote period, have been covered by the sea, but have been recovered by art and industry. They are intersected by ditches, called *droves*, which divide the properties, and are united to larger canals, called *dikes* or *drains*, some of which are navigable by barges. All these fens are below high water mark; in consequence of which, when the drains are filled by the rains, the sluice gates are no longer able to carry off the water; at the same time, the sea-water forces its way through the loose soil. From these two causes, this tract of country is frequently flooded. Parallel to the droves and drains in the fens, are banks on which the roads are constructed. Engines of great power are employed to lift the water from the lower levels into the higher ones, or drains; but, notwithstanding these, the county is frequently under water.

In point of soil, Lincolnshire may be reckoned in general fertile. The soil of the heaths is in general a good sandy loam, on a bed of limestone. The wolds consist of sand and sandy loam, on flinty loam, with a substratum of chalk. The marshes are divided into two kinds; the north marsh comprises a large extent of rich salt lands; the south marsh is composed of strong clay, rather cold, and of inferior value. Between these two marshes is a rich broom loam; and between the wolds and the heath the soil varies considerably. The isle of Axholme, a river-island formed by the Trent, Idle, and Dun, about 10 miles long and 4 broad, contains perhaps the richest soil in Lincolnshire. It consists of black sandy loams, warp lands, brown sand, and rich loams. Between Gainsborough and Newark also is a tract of flat sandy soil, of good quality. This species of soil also prevails from Binbrook to Caiston; but the sand changes into a rich loam near Barton. The soil of the fens is in general rich, being composed of what is called silk. From the account already given of the natural divisions of this county, it will be evident, that, in respect to surface, it is in general uninteresting; it is not, however, so much, or so entirely so, as is commonly imagined. Some parts of the county are rather elevated, especially in the district of Lindsey; and from the wolds and the heaths to the north and south of Lincoln, there are many fine views over the lower regions.

The climate is, on the whole, cold and damp. North-east winds in the spring are more sharp and prevalent than further inland. About the autumnal equinox, strong westerly winds are frequent. Most rain falls in the summer, when the wind is in the north and east. On the low land near the Humber, snow seldom lies long. The fens and marshes are naturally very damp, and the wolds and heaths dry; but cold agues prevail in the former, but not nearly so much as formerly.

The principal rivers of this county are the Trent, Ancholme, Witham, Welland, and Glen. The Trent forms the boundary on the north-west side between Nottinghamshire and Lincolnshire, from North Clifford to Stockworth. It afterwards forms the east boundary of the Isle of Axholme; from thence it flows to Aldborough, where it is joined by the Dun, and afterwards by the Ouse; it then unites with the Humber. It is navigable from Gainsborough. The Ancholme rises in the wolds, and falls into the Humber a few miles below the junction of the Trent; it is navigable to Glandford bridge. The Welland, which rises in Northamptonshire, passes Market Deeping, and then enters the fens. It afterwards divides into two streams, only one of which continues in this county, being carried in an artificial channel to Spalding, where, meeting the Glen, it empties itself into Fossdyke Wash, to the east of Boston. These rivers (with the exception of the Ancholme) neither rise in this county, nor flow through much of it. But the Witham is completely a Lincolnshire river. It rises near South

Witham, about 10 miles to the north of Stamford. Its course is first north, and then east by Grantham. At Long Bonnington it bends again to the north, and flows through a wide sandy valley to Lincoln. From this city its course is east and south-east to Boston, where it enters the sea. The channel of this river being naturally shallow, and little fit either for navigation or for draining the land, an artificial channel has been cut from Boston, a considerable way up the county. There are several other artificial navigations in Lincolnshire. The Fossdyke, which was cut by King Henry I. is an artificial trench, extending about seven miles in length, from the great marsh near the city of Lincoln, to the Trent near Torksey. It is the first canal that was made in England. The Fossdyke joins the artificial channel of the Witham. At Sleaford there is a canal from the Witham to Boston. The Grantham canal goes from that town to the Trent, near Holme in Nottinghamshire. Its length is 30 miles; its fall 148 feet. The Ancholme cut extends from Bishop's Bridge to the Humber at Fezzaby sluice. The Horncastle canal proceeds from that town to the Witham. The Louth canal commences about half a mile from that town, and keeps parallel with the banks of the Leed, by which it is supplied with water. About four miles from Louth, it leaves the river, and, taking a direction to the north, joins the sea at Tetny; its length is about 11 miles.

The sea-coast of Lincolnshire, in general, lies low and flat, or with a small declivity to the east. The extent of sand dry at low water is very great; the difference between high and low water-mark, in some places, extending even to two miles. There are many banks called chain-huts, which are dry at low water: these are composed of roots, trunks and branches of trees, intermixed with leaves of aquatic plants. The trees are chiefly birch, fir, and oak: trunks of great trees are likewise found in the fens. These circumstances prove, that not only the fenny part of the county, but also the coast, has undergone considerable changes. In some parts, the sea has gained on the land, and in other parts it has retired. Wrangle, on the wapentake of Shirbeck, in the division of Holland, now a village between two and three miles from the sea, was a port in the time of Edward III. and sent one ship to the siege of Calais in 1346. Wainfleet, at the same period, sent two, and indeed contiued a haven of considerable consequence, till the stream which flowed near it was diverted towards Boston. On the other hand, the sea has encroached near Skegnesse; this is now a village, but formerly it was a large walled town. According to Leland, walls, town, church, and all, were "eaten up by the sea."

The mineralogy of Lincolnshire is singularly barren, as will naturally be supposed from the description given of its surface and soil. As it is often found necessary to dig to a very great depth for water, especially in the fenny parts of the county, where there are very few springs, the strata have been laid bare to a very great depth in some places: they plainly indicate the alluvial formation of the ground. In boring at the bottom of a well 27 feet deep, a stratum of blue marl was found, of the colour of Westmoreland slate, which continued for upwards of 150 yards, with exceptions, occasionally of only a few inches. But though Lincolnshire is poor in minerals, it is rather interesting in other branches of natural history. In the lower or southern division of the district of Holland are found immense numbers of wild ducks, teal, widgeons, grebes, godwits, wimbles, coots, ruffs, starlings, &c. Near Spalding is the greatest heronry in England. The avoset, or yolper, distinguished by its bill, which bends upwards, is found in great abundance about Fossdyke Wash, and likewise knots and dotterels. The river Ancholme is noted for its fine eels, and the Witham abounds in pikes.

Lincolnshire is distinguished as an agricultural county. Landed property varies much in respect to size. Mr. Young says, the largest estate is about 25,000*l.* a year. In the island of Ancholme, property is very much divided: the inhabitants live in villages, and almost every house is inhabited by a farmer, the proprietor of his farm, of from four or five to thirty or forty acres. These farmers have little money, but they possess nearly all the necessaries of life within themselves. On the wolds also there are many yeomen who farm their own estates; but these are much larger, 300*l.* 400*l.* or even 700*l.* a-year. In the low country, there is much copyhold land, but not much in the higher districts. On the wolds, farms are large, from 500 to 1000 acres. In the fens they are small; in the other parts of the county they are of a moderate size, 150 or 200 acres. Leases are very rare. In the fens, there are several agricultural implements peculiarly adapted to that kind of land; the implements used on the dry land do not require particular notice.

The uplands, open and enclosed, which are nearly double in extent to the enclosed and open marshes and fens, yield grain of all sorts in great abundance; while the lower lands produce oats, hemp, flax, wood, &c.; but, on the whole, it is not as an arable district, that Lincolnshire is celebrated for its agricultural skill or success. According to Mr. Young, the average produce of wheat is about 3½ quarters; the quality however is coarse. The average produce of barley is 4½ quarters; the quality of it also is not very good. The average produce of oats is 6½ quarters; for this grain, Lincolnshire, especially the fens, is justly celebrated. The quantity produced in the fens generally, that is, the fens of Lincolnshire, Northamptonshire, Cambridgeshire, and Norfolk, is supposed to be equal to nearly all the rest of England; and the quality is good. The average produce of beans, according to Mr. Young, is 3¼ quarters per acre. Rape is much cultivated on many of the fens, partly for sheep food and partly for oil. About 50 years there were few turnips grown; at present they are common, but not well managed. Wood is cultivated on the rich loams of the low country, especially on fresh grass lands. The principal demand for it is from Lancashire and Yorkshire. Hemp is much grown near Swineshead and in other parts of the low country. Sainfoin is a favourite and valuable crop on all the soils partaking of chalk; on the wolds it lasts 8 or 9 years; on some of the heath lands 12 or 14 years. In some parts of the isle of Axholme onions are cultivated on a considerable scale; the farmer ploughs the land once, and then lets it at the rate of 5*l.* per acre to those who sow this crop; if abundant, it is worth 50*l.* an acre. The depth and moisture of the soil in the low parts of this county are particularly favourable to cabbages, and they are accordingly grown to a great extent, with considerable care, and in a very profitable manner.

It has already been stated that Lincolnshire is distinguished much more for its grazing than its arable husbandry; the soil of its grazing lands, is a rich loamy clay, some parts of which are stiff, but the whole of it of uncommon and almost unparalleled fertility: Some of the best of these lands lie in the country round Boston. In the year 1796, 20 acres near this town kept 18 cattle and 80 sheep: and there are even instances more extraordinary. Mr. Young mentions 8 acres in this part of the county, which will keep in summer 10 oxen and 40 sheep, and in winter 30 sheep: These are surprising instances of fertility, when it is considered that the sheep are generally of the large Lincoln breed; and the average weight of the oxen reaches 70 stone. Besides the rich grazing lands near Boston, lands of equal fertility for this purpose are found at Algarkirk, Fossdyke, Sutterton, Kirkton, Frampton, Wyberton, &c.; these will carry in summer a bullock or a bullock and a half, besides four sheep, an acre; and two sheep an acre in winter. As the sheep may be estimated at 24 lb. the quarter, and the bullocks at 70 stone each, there will be about 300 lb. of mutton and nearly 400lb. of beef per acre; or suppose the whole mutton, there will be 7¼ sheep per acre in the summer, besides the winter food. In addition to this ought to be reckoned the wool, which cannot be estimated at less than 45¾ lb. per acre. This stocking exceeds that of the richest grazing lands in Somersetshire, and is probably not equalled in any part of the kingdom.

The Lincolnshire cattle are mostly of a large sort, with great heads and short horns. The dairy is little regarded; the rearing of calves is a good deal attended to; but the grand object is fattening cattle for the butcher. The sheep of this county is a large horned animal, weighs well when fat, and bears a heavy fleece of coarse long stapled wool; the weight per fleece is nearly 9 lb. Lincolnshire is stocked with sheep far beyond any other county in the kingdom; according to Mr. Young there are nearly 2,500,000 sheep kept in it, producing nearly 22,000,000 lbs. of wool. Lincolnshire has long been famous for a fine breed of horses; though in consequence of many of them being taken into Yorkshire, and sold at the fairs there, the latter county has deprived Lincolnshire of much of its credit on this score. In the district of Holland, almost every farmer keeps a number of mares for the purpose of breeding. In the neighbourhood of Long Sutton, remarkably fine and useful saddle horses are reared. The finest and best horses in the kingdom, chiefly blood horses, are bred on the wolds.

In connection with the agriculture of the county may be mentioned the rabbit warrens, the decoys, and the geese: the first were formerly much more extensive than they are at present, many being broken up for tillage; yet many thousand acres are still directed to this kind of stock. Those rabbits that are bred in the beginning of May are deemed the best; the clear white skins bring the highest price; after them, what are called the silver grey. Several causes have contributed to diminish the number of rabbit warrens; the decline in the value of their skins; their uncommon and almost indiscriminate voracity, all kinds of herbs, roots, grain, fruit, bark, and branches of young trees, being eaten by them; and lastly, the soil of old warrens being extremely fertilized by the urine and dung of the rabbits, this circumstance also has contributed to the decrease of this animal. The most considerable and numerous decoys are in the Holland division of this county. They are formed of pools surrounded by woods; from these pools there are small drains called pipes. When the proper season arrives they are covered by nets, and by means of a decoy bird the wild foul are induced to enter the pool through the drain thus covered: when they have entered the channel, the net is drawn, and they are inclosed and taken; the general season for catching is from the end of October till February. The decoys of Lincolnshire supply the London market with wild fowl; the number taken is immense: it is said that 10 decoys in the west fen during one winter supplied 31,200. Geese are plucked five times a year in general; in some parts only three or four times. The first plucking at Lady Day is for quilted feathers. The feathers of a dead goose are more valuable than those of a live one, but only as being in larger quantity; by the pound the feathers of a live goose are more valuable. The practice of plucking alive has prevailed ever since feather-beds came into general use; three dead geese yield a pound of feathers.

Besides the usual modes of improving land by manures, &c. Licolnshire has been much improved by drainage, paring and burning, and manuring. From the nature of its surface, especially in the south-east parts of of the county, it is evident that no substantial benefit could be derived, except by previous drainage carried to a greater extent, and on a more substantial plan than any other part of the kingdom required. According to Mr. Young, "without going back to very remote periods, there cannot have been less than 150,000 acres drained and improved on a rental created of at least 150,000*l.* a-year." Paring and burning has been practised with great success in many of the fens, after they are thoroughly drained, especially in deepening fens; it has also been carried on with advantage on Lincoln heath and the wolds. But the most singular and beneficial mode of improvement practised in Lincolnshire is warping; this may be shortly described as permitting the tide to flow over the land at high water, and letting it off at low water. The water of the tides that come up the Ouse, Trent, Dun, and other rivers which form the Humber, is extremely muddy; by permitting these waters to flow over the land and remain there till the returning tide carries them off, the soil will be raised in the course of one summer from 6 to 16 inches; and this deposited soil is of the richest quality, consisting of argillaceous and siliceous earth, with a very large proportion of mucilage. In order to warp land, a canal is made from the river, with a sluice at the mouth; and that the water may be of a proper depth on the land to be warped, and also to prevent its flowing over the adjoining lands, banks are raised round the fields that are to be warped. Hence it will be evident that the expence is very great, but the wonderful fertility thus bestowed on the lands fully compensates for it.

Lincolnshire is not distinguished for its manufactures; at Gainsborough there is a pretty large manufactory of brushes and coarse hemp sacking. About Normanby, Barton, &c. flax is spun and woven into linen, but not to any extent. Spinning schools have lately been established in the southern parts of the county, but they do not seem to thrive. There are several large fairs in the county; that of Horncastle is particularly noted for the number and excellent quality of the horses sold at it.

No county in the kingdom is more celebrated for its ecclesiastical architecture than Lincolnshire; and this character applied to it in former times with even greater justice and propriety than it does at present. It deserves to be noticed, "that the most splendid edifices which adorn this district were erected chiefly in its lowest and most fenny situations, where all communication must formerly have been, and even to this day is, extremely difficult. The most beautiful ecclesiastical edifices are in the districts of Kesteven and Holland; those in the division of Lindsey (with the exception of Lincoln Cathedral) are in general inferior, but in the north eastern part of Lindsey, a low flat tract, there are several churches of elegant and rich architecture. The date of them is from the reign of Edward III. to that of Henry VII.; they are built of excellent materials, and, with only two exceptions, their form and character vary very little. In the central part of Kesteven most of the churches are adorned with lofty spires; in the northern and southern parts with towers; their general date is from the 13th to the 15th century; many of them are excellent specimens of ancient English architecture. In the district of Holland, however, the ecclesiastical architecture of the county appears in its richest style, and with the greatest abundance; in this fenny district are the churches of Boston, Gosberton, Pinchbeck, Spalding, Holbeach, Gedney, Long-Sutton, Croyland, &c. all of which are celebrated for their architectural magnificence or beauty. As at the period of their erection, Holland was a complete fen, accessible in many parts only by water, it was necessary to lay artificial foundations of piles or planks of wood, or different layers of earth and stone; and yet such was the skill and care of the architects, that notwithstanding these difficulties few of the churches have swerved from the perpendicular. Their form varies, some are cruciform, many have spires; while others have embattled towers at the west end. Only a small part of the very celebrated abbey of Croyland remains; when entire, it must have been equal in size, and not inferior in architectural ornament, to any of the cathedrals of England. The church of Long Sutton is supposed to be the earliest specimen of architecture in Holland, and may be regarded as the counterpart of the cathedral of Christ-Church Oxford. In this part of Lincolnshire there are few churches of a later date than Edward III.; some have been referred to the Anglo-Saxon period of our history. The stone employed in their erection must have been of most excellent quality, as it still retains its original force and firmness. Before the Roman conquest, Lincolnshire was inhabited by the Coritani. During the dominion of the Romans, it was included in the province of Britannia Prima. The whole of the present county is supposed to have been named by them *Lindum*, and the principal station or town Lindum Colonia. During the Anglo-Saxon period, Lincolnshire formed part of the kingdom of Mercia. Since that period this county offers scarcely any historical events worth noticing. King John, in the Barons wars, lost all his carriages and camp equipage, with many men, by the quick sands, in passing the Wash at low water.

The poor-rates and other parochial rates for this county amounted in the year 1776 to the sum of 35,632*l.*; the average amount for the years 1783, 1784, and 1785, was 47,190*l.*; in the year 1803 they had risen to the sum of 145.848*l.*; the average of the county at this period was 3s. 7d. upon the actual rent. The number of poor people relieved in workhouses in 1803 was 1112; the expence of so maintaining them amounted to 14,936*l.*; or at the rate of 13*l.* 8s. 7¼d. per person. The number of poor supported out of workhouses was 17, 733, besides 3091 not parishioners; the expence of maintaining them was 80,638*l.*; or at the rate of 4*l.* 10s. 7d. each person; taking those who were returned both in and out of workhouses, the expence of maintaining them was at the rate of 5*l.* 6s. 9d. each person; of the resident population 9 in 100 were relieved. The sum of 14s. was raised by parochial rates on the population of the county; the amount of the whole expenditure for the poor was at the rate of 9s. 8d. on the resident population. In the year ending the 25th of March, 1815, there had been raised by poor-rates or other rates, in the 756 parishes or places contained in Lincolnshire, the sum of 226,997*l.* 18s. 2½d. In the year 1803 there were 22 friendly societies in the district of Kesteven, and 19 in Lindsey: there were no returns from the district of Holland. Four in 100 of the population belonging to friendly societies.

In the year 1700 the population of this county was rated at 180,000. In the year 1750 it seems to have diminished, the number being calculated only at 160,200; in 1801 the number was 215,500, inhabiting 41,395 houses; this population gives 75 to the square mile. In the year 1811 there was one baptism to 32 persons, one burial to 51 persons, and one marriage to 126 persons. In the same year the following were the results of the returns to the Parliamentr especting the population.

Houses inhabited	46,368
Families inhabiting them	50,904
Houses building	276
——— uninhabited	1099
Families chiefly employed in agriculture	29,881
——— in manufactures, &c.	13,184
——— not included in the above	7839
Males	117,022
Females	120,869
Total	237,891
Population in 1801	215,500
Increase	22,391

LINDISFARNE. See HOLY ISLAND.

LINDAU is a town in the kingdom of Bavaria, situated upon an island in the lake of Constance. The island, which is 4450 paces in circumference, communicates with Swabia by a bridge 300 paces in length. An arm of the lake divides the island into another smaller island, which is separated from the city, and contains a vineyard and garden, enclosed by a wall. The principal public buildings and antiquities are, a parish church, a well endowed hospital, a grammar school, the building called *die Burg*, erectedunder the Emperor Constantius Chlorus, and a wall called the Heidenmauer, or the Heathen Wall, supposed to have been built by Tiberius Nero.

From the north-west part of the island, in the fine gardens which surround the town, also from the bridge, there is a charming view of the lake of Constance in all its extent, and as far as the fortress of Hohentwiel, a distance of 20 leagues. The view of the opposite shore of Switzerland from the country-house of M. Seiler is also very grand. When the air is clear, the city of Constance may be seen through a telescope, at a distance of 11 or 12 leagues. Population 6000. East Long. 10° 35′. North Lat. 47° 31′ 44″.

LINLITHGOW, a royal burgh of Scotland, and capital of the county of Linlithgow or west Lothian, is situated on the great road from Edinburgh to Stirling, at the distance of 16 miles from the former. The town consists principally of one street, stretching nearly a mile in length, and intersected by several small streets or lanes. Although many of the houses are very old, which gives the town a ruinous appearance, yet it contains a number of excellent buildings.

The principal public buildings here are, the palace, the church, and the town-hall. The ruins of the palace, which cover an acre of ground, stand to the north of the town, upon an eminence which stretches into an extensive lake, which adds greatly to its beauty. The building is constructed of hewn stone, and has in its centre a handsome square; one side of which, built by James VI. is more modern than the rest. There is on one part of the building a magnificent room, 90 feet long by 30½ feet wide, and 33 feet high, at one end of which is a gallery of three arches. The apartment in which Mary Queen of Scots was born, on the 8th October, 1542, has also been a handsome one. The palace was well preserved till the year 1746, when it was converted into barracks, and a great part of it burnt by the king's troops. Since that time it was suffered to fall gradually into decay; but the Barons of Exchequer have, much to their honour, interfered for its preservation.

The church of Linlithgow, annexed to the palace, is an old and handsome building, containing several beautiful windows, and adorned with a handsome spire, surmounted by an imperial crown. The whole of it lately underwent a thorough repair. The aisle is still shewn in which James IV. is said to have seen an apparition, warning him of his fate at the battle of Flodden.

The town-house of Linlithgow, which was built in 1668, is both elegant and commodious. An ancient and highly ornamented cross formerly stood in front of it, with eight spouts from which water flowed. It has lately been replaced by a new one of a similar construction. The house from which Hamilton shot the Regent Murray, in the reign of Queen Mary, is still shewn to strangers. Linlithgow is governed by a provost, four bailies, a dean of guild, twelve merchant counsellors, and the deacon of the eight incorporated trades. This burgh is joined with Lanark, Selkirk, and Peebles, in sending a member to parliament.

The town formerly carried on a considerable trade. It had then an exclusive right of trade from the Water of Cramond to the mouth of the Avon, and many warehouses were erected at Blackness Castle, which was its port. After the union of the two crowns, however, these advantages disappeared.

The chief manufacture in Linlithgow is that of leather, and shoemaking is carried on to a considerable extent. The woollen trade also thrives here, and there has lately been established a very extensive bleachfield, which employs about 300 persons. Population of the town in 1811, 306 houses, 680 families, 424 employed in trade, 2557 inhabitants. The total population of the parish is 4022.

LINLITHGOWSHIRE. See Lothian, West.

LINNÆUS, Sir Charles, the most distinguished naturalist of modern times, was born May 3, 1707, (O. S.), at Rashoolt, a village in the province of Smaland, in Sweden. His father Nicholas was a country clergyman. The surname of *Linnæus*, *Lindelius*, or *Tiliander*, as it was sometimes called, is said to have been derived from a large Tilia or Linden-tree, which grew near to the native place of the progenitors of this clergyman. His mother's name was Christina Broderson. The father amused himself with the cultivation of curious and ornamental plants; and young Linnæus evinced very early a decided taste for botanical pursuits. At the age of eight he was in the habit of ranging over the neighbouring fields and woods in search of uncommon plants, introducing all kinds that he found into a corner of the parsonage garden allotted to his use; and even at this tender age, the ardour of his spirit for investigation was proved by his bringing to this spot, and endeavouring to domesticate, hives of wild bees which he found in the woods. When about ten, he was sent to the grammar school at Wexico, the principal town of Smaland,—his parents intending to educate him for the church. Here he continued to show the same predilection for objects of natural history: when he should have been poring over his lesson, he was too often hunting the fields in search of plants or insects. The rector of the school, however, happening himself to have a turn for the study of nature, did not discountenance him, nor despair of the ultimate success of such a pupil. After having spent seven years at this school, he was removed to the higher seminary, or college of Wexico. Here his deficiency in academical acquirements, especially such as were preparatory to the acquiring of holy orders, became more evident; and the well-meaning father of Linnæus, seeing no prospect of his son's ever filling a pulpit, determined, after a struggle with his feelings, that the lad should learn a trade, by which he might gain a livelihood, and proposed to bind him apprentice to a shoemaker! This strange fate was averted by the benevolent interference of Dr. Rothmann, Professor of Medicine at Wexico, whose penetration and judgment enabled him to form a just estimate of the intrinsic value of the talents of Linnæus, should they be properly directed. This kind-hearted physician received him into his family, and treated him as a favoured pupil. Here the young naturalist first had access to the writings of Tournefort, particularly the *Institutiones Rei Herbariæ*. This excellent work became the torch which illuminated his early path, and was thus the source of that more powerful light which the Linnæan writings afterwards diffused. Having in this way been enabled to spend about three years at college, he resolved to prosecute his studies at the university of Lund, in Scania. Professor Humærus of this university was a relative of Linnæus, and had promised to befriend him; but, unfortunately, the youth arrived in time only to witness the funeral of his expected benefactor. This disappointment was in a great measure compensated by the kindness of Professor Stobæus, who, like Rothmann, had discernment to perceive the uncommon merits of Linnæus, and, like him, possessed a feeling heart. The library of Stobæus was considerable, and Linnæus now had access to the works of the principal naturalists, ancient and modern: he continued to make rapid progress, therefore, in the study of natural history.

After spending about a year at Lund, being still impelled by an ardent thirst for knowledge, he set out for Upsal. During his attendance at the university here, —of which he was destined afterwards to become the brightest ornament,—he experienced great difficulties on account of his slender means. For about twelve months he suffered all kinds of privations, labouring under what he emphatically calls "graviora pauperis onera. Olaus Celsius, the Professor of Divinity, was at that time the first botanist in Sweden; but he was unluckily absent on a protracted visit to the capital. Soon after his return to Upsal, happening to encounter Linnæus in the Physic Garden, he was immediately charmed with his zeal and intelligence; and the indigence of the youth being now apparent, Celsius not only relieved his necessities, but received him into his house: another motive was perhaps combined with benevolence; he probably was not displeased to procure so able an assistant in his work (*Hierobotanicon*) on the plants mentioned in the Sacred Scriptures. It was at this period that Linnæus projected his Sexual System of Botany, and thus laid the foundation for his future fame. He had studied the little treatise of Vaillant, *de Structura Florum*, and had been thus led to form a correct opinion as to the importance of the stamens and pistils.

Rudbeck, then Professor of Botany at Upsal, was not insensible to the merit of Linnæus, and he soon became the means of greatly promoting his career. Feeling the infirmities of age, he was desirous of an assistant lecturer; he applied to Linnæus; and, in 1730, when in his 23rd year, did this promising naturalist deliver the course of botanical lectures at Upsal, with high approbation.

He continued in this situation, till the Academy of Sciences at Upsal invited him to visit Lapland, and give an account of its natural productions. This proposal he could not resist, always feeling the strongest desire of examining strange countries. The sum granted by the academy, in name of travelling expences, amounted to no more than 7*l.* 10*s.* Sterling; an allowance suited perhaps to the nature of the country, but which it must have required all the economy of a frugal student to render sufficient. On this trifling sum did he travel 800 German leagues, during six months. The devotedness with which he fulfilled this mission, and the hardships he endured, are excellently unfolded in his diary,— the *Lachesis Lapponica*, published long after his death. This journey was followed by the appearance of the *Florula Lapponica*, one of his earliest publications. Even in this Florula, he abandoned the system of Tournefort, and arranged plants according to the number and position of the stamens and pistils.—In reward for his diligence, and as a mark of approbation, he was elected a member of the Academy of Upsal.

In 1733, Linnæus endeavoured to provide for himself, by giving private lectures on botany, chemistry, and mineralogy, at Upsal; but, according to the statutes of the university, no one was permitted to do so, who had not taken a degree. Linnæus, on account of his poverty, was in this predicament; and Rosen, the professor of anatomy, having informed against him, and insisted for the application of the law, the lectures were necessarily discontinued. He was now invited by some of his former pupils to accompany them on an exploratory visit to the extensive copper mines at Fahlun in Dalecarlia. Having in this way become known to Baron de Reuterholm, governor of Dalecarlia, he received the charge of his two sons, with directions to travel with them through the province, and examine its natural productions in general. After this delightful excursion, he returned to Fahlun, and delivered a course of lectures on the art of assaying metals, and on mineralogy. His pupils were few; but his pressing wants were supplied by the moderate fees he thus received. Here he formed acquaintance with the family of Dr. Moræus, the physician of the place; and this had a powerful influence on his future life; for he became attached to Sarah-Elizabeth, the eldest daughter of this physician. The young lady returned the affection, and so frankly avowed it, that she even furnished him with the pecuniary means of taking a medical degree. With this view he set out for Harderwyk in Guelderland, as the most economical university to which he could repair.

In travelling towards Holland he visited Hamburgh, from which a curious circumstance tended to hasten his departure. The secretary of the council of Hamburgh possessed what was considered as a unique natural curiosity, a serpent with seven heads—the reality of which had never once been called in question; and this precious specimen had been deposited with the worthy secretary in security for the loan of 10,000 marks. The penetrating eyes of Linnæus detected the imposture which had been practised; the serpent's many heads he perceived to be made up of the jawbones of weasels; and this fact having been suffered to transpire, the innocent discoverer of the imposition found it prudent to decamp. Preparatory to receiving his degree at Harderwyk, he published a thesis, in which he alleged that water impregnated with argillaceous matter was a principal cause of the cold intermittent fever of Sweden; a hypothesis probably altogether groundless, and which he defended merely as a *pensum academicum.*

In all his peregrinations, and in his mode of living, he suited his expences to his limited resources, constantly exercising the most scrupulous economy. He uniformly travelled on foot, and always contented himself with the homeliest fare and accommodations. Yet his finances were nearly exhausted, when, having gone to Leyden, his uncommon merit attracted the notice of the distinguished botanists at that seat of learning. By them he was encouraged to print the first edition of the *Systema Naturæ*, which appeared in a tabular form, in 14 folio pages. The illustrious Boerhaave was then advanced in years, and so completely occupied with important concerns, and with visitors of distinction, that the unpretending Linnæus had for some time found it impossible to obtain an interview. His little publication, however, soon procured him not only that honour, but the friendship and patronage of this eminent physician. He gave him a letter of recommendation to Dr. Burmann, Professor of Botany at Amsterdam, who was then engaged in describing the plants of Ceylon. The professor was greatly struck with the uncommon talents of Linnæus. He asked him to reside in his house and assist him in his labours, a proposal which was readily accepted.

The year 1736 opened a prospect to Linnæus which superseded for a time his intended return to Sweden. Dr. George Clifford, a rich burgomaster of Amsterdam, was then the most distinguished cultivator of plants and collector of natural curiosities, perhaps, in Europe. To this gentleman did Boerhaave recommend the young Swedish doctor, to act at once as his physician and assistant naturalist. He removed, therefore, to Clifford's villa of Hartecamp near Haarlem, which was almost entirely laid out as a garden, and which, under his auspices, soon rose to pre-eminence for its botanical collection. Here Linnæus spent some of the happiest of his years, enjoying literary ease, free from all anxiety concerning pecuniary matters, and treated by his patron as a friend and companion. It was during this propitious interval that he digested those systematic arrangements, which soon changed the face of natural history, and which have almost identified his name with the science. Even during the first year of his residence at Hartecamp, he produced three small works: 1. The *Fundamenta Botanica*, (afterwards extended, and published under the title of *Philosophia Botanica*); 2. *Bibliotheca Botanica*; and, 3. A tract entitled *Musa Cliffortiana*, being a description of a banana tree (M. paradisaica) which had flowered in the garden at Hartecamp. He soon enjoyed, what he had greatly longed for, an opportunity of visising England. Clifford was particularly anxious to obtain North American plants, for which the gardens of Chelsea and Oxford were then famous; and with the view of procuring these, he proposed that Linnæus should take a journey to England. Our readers, we presume, will not be displeased, if we be somewhat particular in giving an account of the visit of this wonderful genius to our island, even though it should appear that the reception he met with was not very creditable to the leading botanists of that day.

He embarked at Rotterdam about the end of July 1736, and landed at Harwich. He immediately went to London, and presented himself to Sir Hans Sloane, then president of the Royal Society, with a letter of recommendation from Boerhaave, expressed in the warmest terms: "Linnæus qui has tibi dabit literas est unice dignus te videre, unice dignus a te videri." Notwithstanding such a recommendation from this great physician, who was known to be incapable of the arts of flattery, Sir Hans received Linnæus rather coldly, probably because he felt disinclined, at an advanced period of life, to listen to novelties or reforms in the science of natural history, over which he had long reigned in England. How different (may we not remark, in passing,) would have been the reception of the Swedish youth by the illustrious man who has presided over the Royal Society for the last twenty years, (Sir Joseph Banks,) who extends his liberal and enlightened patronage to every ardent and ingenious cultivator of science, of whatever country, and whose venerable countenance never fails to express the pure joy of his heart when he witnesses the advancement of true knowledge, even though favourite opinions should be overturned in its progress. Linnæus, however, enjoyed an opportunity of inspecting the Sloanian cabinet and herbal, both of which were treasures of their kind.—The Apothecaries' Garden at Chelsea was then under the management of the celebrated Philip Miller, well known as the author of the great Botanical Dictionary. Linnæus soon paid a visit to this garden. Miller was fully aware of the fame of Clifford, and, therefore, personally conducted Linnæus among his rarities, but employed only the old nomenclature. Linnæus said very little: his silence was, simply enough, ascribed to ignorance, and gave occasion to some unlucky taunts, on the part of Miller, against the "burgomaster's botanical missionary." On further acquaintance, however, our countryman altered his opinion of this missionary, freely presented him with whatever plants he wanted, and established a correspondence with him. Indeed, Miller at length adopted the Linnæan arrangement and nomenclature; thus proving that he was himself well versed in the science of botany, and capable of appreciating the merits of the new system.—The Oxford garden was the next object. Here the most eminent botanist at this time was Dellenius, author of the *Hortus Elthamensis*, and who was then engaged in those researches in the tribe of Musci, which afterwards procured him the highest botanical reputation. Dellenius had found in William Sherard, formerly English consul at Smyrna, such a friend as Linnæus had met with in Clifford. The young foreigner now surprised Dillenius in company with his patron. Linnæus having apologized in Latin for his inability to speak English, Dellenius was thrown off his guard, and carelessly said to Sherard, "This is the young man who would confound all botany." Linnæus gathered the meaning of this speech, by tracing the verb *confound* to its Latin root; and he soon took an opportunity of retaliating, by slightly alluding to it while he was demonstrating in the garden some of the new genera to which Dellenius had particularly objected. He soon constrained the Oxford professor to form a high opinion of his abilities; but he could never succeed in making him a proselyte.—Linnæus returned to Holland in the end of September, with a rich store of curious plants for the garden at Hartecamp.

The next year (1737) was perhaps the most active of his literary life. In the course of it he published about 200 printed sheets, constituting seven different works. These were all originals, and are still regarded by naturalists as standard productions. No doubt, the materials had, in a great measure, been previously collected, and one book sprung from another; but still the digesting and arranging of materials so voluminous and multifarious afforded ample evidence, not only of singular diligence, but of a wonderfully comprehensive and vigorous mind. The first of these works was the *Genera Plantarum*, in which he described 935 genera. To this he added, within a few months, a *Supplement* (*Corollarium Generum*,) containing 60 new genera. The well known *Flora Lapponica* succeeded. Then came the superb *Hortus Cliffortianus*, extending to 500 pages in folio, with 32 plates engraved by Ehret; and a small book, called *Viridarium Cliffortianum*. The *Critica Botanica* followed, a work, in which, with great perspicuity and judgment, he exposed the faulty nomenclature which had hitherto prevailed, and showed how it could be remedied.—In the close of this busy year, he left Hartecamp, and fixed his residence at Leyden, where he assisted professor Van Royen in giving a new arrangement to the botanic garden. During this interval, he published the *Ichthyology* of his ill-fated friend Artedi (who had been accidentally drowned); and also a thick octavo, entitled *Classes Plantarum*, in which he detailed and criticised with ability and candour all preceding systems of botany.

Linnæus received successively from his Dutch friends the offer of being sent as physician to the settlement at Surinam, or as botanist to the colony established at the Cape of Good Hope. He rejected both proposals; his usual cheerfulness and buoyancy of temper had deserted him, and he seemed to be falling into ill health. The unremitting application of the preceding year might perhaps have tended somewhat to impair his constitution. The chief cause of his malady, however, was of a different nature. He had kept up a correspondence with the daughter of Moræus; but a pretended friend had proved false, and had endeavoured to supplant him. A surmise of this kind having come to his ears, he could not rest till he should revisit Fahlun. No sooner had he taken the resolution to do so, than he began to recover his health and his ardour for science. He mustered spirit enough to dedicate a whole month to a visit to Paris. Here the celebrated Bernard de Jussieu received him with great kindness, and a friendship was formed equally honourable to both. Through the good offices of Jussieu, Linnæus had the distinction conferred of being admitted, at this early period of his life, a corresponding member of the Academy of Sciences. He intended likewise to have visited Baron Haller at Göttingen; but his impatience recurring, he embarked at Rouen, in a vessel bound direct for a Swedish port.

Having satisfactorily arranged his affairs at Fahlun, Linnæus determined to settle in Stockholm in the autumn of 1738, after an absence of three years and a half from Sweden. Here his acquirements in natural history were at first of little avail. He found it necessary to resort to medical practice for his support; and in this profession his character as a botanist rather operated to his disadvantage. His intrinsic merits, however, gradually promoted his rise; and, in the course of the following year, he received a testimony of approbation from the most learned man of the age, which must have been peculiarly gratifying, and which formed a striking contrast with the neglect he had previously suffered from his own countrymen. This consisted in the illustrious Haller inviting him to Göttingen, to become his assistant and successor. It so happened, however, that the prospects of Linnæus at home having begun to brighten, he declined the flattering proposal. Count Tessin, the distinguished Swedish Statesman, now patronized him, and obtained for him the appointment of physician to the Admiralty. Being thus secured in a regular income, he was enabled to accomplish the long delayed matrimonial alliance. About this period, Linnæus procured the establishment of the Academy of Sciences of Stockholm, the plan of which was suggested by him, and he was chosen its first president. By this measure he signally promoted the advancement of the sciences in his native country.

In the year 1740, on the death of Rudbeck, professor of botany at Upsal, Linnæus made application for the vacant chair; but he was not successful. Some time afterwards, however, through the interest of Count Tessin, he obtained the professorship of physic and anatomy in that university; and having effected an interchange with the person who had been appointed to the botanical chair, he thus attained the great object of his ambition. The Upsal botanic garden soon eclipsed all others in the north, the government having granted funds for its restoration and embellishment, and Linnæus supplying all the other requisites for the success of such an establishment—unwearied zeal, and great knowledge, both of botany and horticulture*.

For a long series of years after this, the fame of Linnæus continued to increase, and his lectures attracted students to Upsal, many of whom became afterwards distinguished as naturalists.—He now attended, in a particular manner, to the natural history of his own country; and, in 1745, published the *Flora Suecica*, which was succeeded in the following year by the *Fauna Suecica*.

The father of Linnæus, who had been so often grieved at the perverseness of his son's disposition for hunting after plants and worms, to the neglect of Latin and Greek, and who had therefore concluded that he was fit only to be a maker of Swedish brogues, fortunately lived to see him not only professor of botany, but raised to the dignity of archiater or dean of the College of Physicians of Upsal, caressed by the grandees of Sweden, and honoured by all the literati of Europe. The good old man died in 1748, still in the station of a village preacher; and certainly, but for his wayward son, his name had never reached our time.

In 1751, Linnæus published the *Philosophia Botanica*, (founded, as already noticed, on the *Fundamenta Botanica*,) which remains to this day a code of precepts to botanists. The opinion which Rousseau gives of this work,—"C'est le livre le plus philosophique que j'ai vu de ma vie,"—is striking, and forms a singular contrast to the "faint praise" of some, who, while they laud the industry of Linnæus as a naturalist, seem inclined altogether to deny to him the character of a philosopher.

Linnæus had for a long time indulged the idea of accomplishing a uniform arrangement and description of all known plants. He had not only diligently studied every preceding writer, but had himself visited the best gardens in Europe, and examined the most celebrated herbariums; while his botanical pupils were now spread over a great part of the globe, and transmitted to him ample store of new plants. He possessed therefore many advantages; and he had acquired great readiness and facility in fixing on the characteristic marks of plants, and in describing these in appropriate terms. In preparing the *Species Plantarum* for the press, Linnæus bestowed much attention on two objects which had hitherto been very much neglected,—correctness of synonymy, and simplicity of nomenclature. The descriptive names of species of plants, or *specific* names properly so called, were in general uncommonly long, consisting often of a whole sentence: to remedy this, Linnæus invented what he called the *trivial* name. This generally consists of a single word, often an adjective, expressive of some quality of the plant, or of some remarkable circumstance attending it, most likely to dwell on the memory. This improvement has received the sanction of all subsequent botanists, having been adopted equally by those who prefer the Jussieuan method, as by those who adhere to the Linnæan system. To describe accurately, to determine the synonymy, and to reform the nomenclature of several thousand plants, was a vast and a difficult undertaking, which could have been accomplished only by such a man as Linnæus, who, to wonderful acuteness of mind, added solid judgment and indefatigable perseverance. Some writers (we regret to number Lord Kames among them) who speak slightingly of this part of the labours of Linnæus, only prove that they have not studied the subject on which they pronounce judgment. It will be found, that those whose tastes and pursuits have best enabled them to form a just estimate of the difficulty of the undertaking, and of the ability with which it was accomplished, have uniformly expressed the highest admiration. To give only one example; Haller styles it, "Eximium opus, immortalitate dignum." The Species Plantarum may therefore justly be regarded as one of the best productions of Linnæus, and as forming an accurate and complete digest of botanical knowledge at the time of its appearance in 1753. Only between 7000 and 8000 plants were then known. The number of species now described considerably exceeds 30,000;—thanks to Linnæus, who led the way to this splendid advancement of botanical knowledge.

While, however, the great merit of Linnæus in botany, consists in the invention of the new and comprehensive, although artificial system founded on the sexes of plants,—on his having constituted the genera on better principles—and bestowed more proper and convenient names, it is not to be concluded, as seems sometimes to have been done, that he neglected, far less despised, what is called the Natural Method. On the contrary, he considered that the artificial and the natural methods should go on together; he proposed 65 Natural Orders; and, regretting his inability to proceed farther, declared that the highest honours would redound to that botanist who should hereafter be able to complete the design.

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* The Upsal Garden, as left by Linnæus, ought for ever to have remained sacred; but we regret to say, that a new botanic garden having of late years, been formed, the garden of Linnæus is now (1818) in ruins, with cows grazing in it!

The diligence of Linnæus in composing and in editing works on natural history, was almost beyond conception. In the course of a few years, between Travels, Floras, Essays, and Descriptions of Museums, he produced about thirty different publications*. Among these, the enlarged edition of the *Systema Naturæ* holds the most conspicuous place, and would of itself be sufficient to perpetuate his memory. In a short space of time it passed through several editions, always receiving improvements from the author. In 1766, the 12th edition appeared, in three volumes 8vo. This was the last which was corrected by the author himself; it is justly accounted the best, and, being much in request, has now become rather a scarce book.

To enter, in this place, upon any more particular account of the writings of Linnæus on the different branches of natural history, or to detail the principles of classification which he adopted in each, seems unnecessary. For, such is the celebrity which these writings have acquired, so generally have they been founded on by naturalists, and so predominant have their ascendancy and influence become, that an account of their respective contents must necessarily be interwoven with the history of each department of the science. Under the article **BOTANY**, for example, will be found a full explanation of his botanical reforms; under **AMPHIBIA**, a history of his arrangement of animals, which, according to his views, were of an amphibious nature; and under **ICHTHYOLOGY**, an account of his mode of disposing Fishes, founded on the method of his friend Artedi. In like manner, in the articles **MAZOLOGY**, **ORNITHOLOGY**, and **ZOOLOGY**, further details will appear respecting the Linnæan arrangement of Quadrupeds, Birds, and other animals. In Mineralogy, Linnæus shone less perhaps than in any other department of natural history. But so great, of late years, have been the discoveries and improvements in this branch of science, that it is perhaps difficult to do justice to the merits of the Swedish naturalist. He was the first who established generic characters of minerals, and he described 54 genera. See **MINERALOGY**.

But Linnæus, in his writings, did not confine himself entirely to natural history. The science of Medicine was in no small degree promoted by him, especially by his illustrations of the Materia Medica. (See **MATERIA MEDICA**.) In 1749 he published, at Stockholm, a treatise on medicines derived from the vegetable kingdom; and, in 1752, at Upsal, other two treatises on those from the animal and mineral kingdoms. The great energy and utility of medicines taken from the mineral regions were not then well understood; and it was natural, therefore, that the first and most important place should be given to those of vegetable origin. The medical writings of Linnæus are depreciated by Vicq. d'Azyr; but it may be remarked, that Haller eulogises the Materia Medica, and that Cullen speaks favourably of the Genera Morborum of our author; and both were certainly most competent judges. His labours on dietetics were never given to the public in a separate publication; but he printed different detached essays connected with this subject, such as those on the esculent plants of Sweden, on tea, and on coffee.

So bold a reformer was not likely to escape the assaults of critics, and the contumely of envious rivals. His time being fully engrossed by more pleasing avocations, he never answered the attacks made upon him; often passing them over, in reciting a Swedish proverb, which imported, that he who is right, never fails to get justice at the long run. In 1758, it may be remarked, the writings of Linnæus were condemned at Rome as heretical: but fifteen years after, the enlightened Ganganelli, (Clement XIV.) not only rescinded the condemnatory act, but dismissed a professor of botany for not understanding the Linnæan system.

Linnæus had been invited to Madrid, with munificent proposals, and also to Petersburgh; but, preferring his native country, he rejected both. His patriotic predilection did not remain unrewarded. Honours of different kinds were successively heaped upon him. In 1753 he was created a knight of the royal order of the Polar star, an honour which had not hitherto been conferred on any literary character; and, in 1757, he was raised to the rank of hereditary nobility in Sweden, from which time he was usually styled *De Linné*. Nor was it only in Sweden that his merits were acknowledged and rewarded: from other countries he received honours dearer to a man of letters, and in reality of a higher nature, than any which Sovereigns can bestow,—those which flow from the free suffrage of learned societies. In 1762 he was elected an ordinary member of the Royal Academy of Sciences at Paris, and in the following year, of the Royal Society of London.

Always fond of rural employments, Linnæus enjoyed a further opportunity of gratifying his taste, when his prosperous circumstances enabled him to purchase the villa of Hammarby, about three miles from Upsal. Here he usually spent the summer, and was constantly engaged in improvements. He erected a little museum on an eminence commanding the whole district; and to this retirement, during vacation time, he often invited some of his favourite pupils, especially foreign ones, and there instructed them—not equipped in the robes, and assuming the state of a professor, but frequently in his morning gown and slippers, with a red fur cap on his head, introducing his remarks in the manner of a friendly companion. Botanical studies, we have seen, were the first to engage the youthful mind of Linnæus; in these he persevered through life with delight; and on the advancement which he lent to the science of Botany, will his future fame chiefly rest. So ardent did his passion for plants remain, even after his health had begun to decline, that disease was sometimes put to flight by the mere acquisition of botanical treasures. He was lying ill of the gout, and unable to move, when Kalm arrived from America; but the sight of the transatlantic rarities brought home by this zealous collector so roused his spirits, that he soon found the use of his limbs, and conquered the malady. For this disease, it may be mentioned, he strenuously recommended living on fruit, especially strawberries, which, in his case, seemed to operate like a specific.

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* Epistola de itenere Lapponico; Epistola de filicibus; Mantissa plantarum; Mantissa altera; De Memorabilibus in Insectis; De peregrinationum intra patriam necessitate; Travels through Oeland and Gothland; Travels through Sweden; Hortus Upsaliensis; Hortus Ferberi; Iter Scanium; Iter Palestinum (Hasselquist); Iter Hispanicum (Loefling), Flora Zeylanica (Burmann); Flora Belgica; Flora Alpina; Plantæ rariores Norvegiæ; Flora Capensis; Plantæ Africanæ rariores; Plantæ Kamschatkenses; Flora Jamaicensis; Plantæ Surinamenses; Deliciæ Naturæ; Museum Tessinianum: Museum Regis Adolphi; Museum Reginæ Ulricæ, &c. Many little pieces by Linnæus appeared in the Transactions of the Academy of Sciences of Upsal, and in the Transactions of the Royal Academy of Sciences at Stockholm. The Amœnitates Academicæ, in 7 vols 8vo. likewise embrace many important little essays by Linnæus. A selection from these was many years ago published in English, in one volume 8vo. and is commonly known by the title of *Stillingfleet's Tracts.*

In the month of May 1774, Linnæus was seized with an apoplectic fit. This, it has generally been believed, was immediately brought on by the shock given to his feelings in the publication of the *Epistolæ ad Hallerum*, among which was included, without consulting him, a confidential letter regarding his courtship and early prospects. From this stroke he never recovered: he lingered indeed for almost four years, but these were years in which it might be truly said, that "he had no pleasure in them."

In 1776, the King of Sweden, seeing the distinguished naturalist fast declining, doubled his pension, and authorized him to employ a deputy to teach his class. He fortunately found in his only son, an assistant every way qualified for the task; and young Charles Linnæus was appointed to this office, with the promise of succeeding to the chair. From about this time the father sunk into a state of lethargy, in which he continued for many months. He expired on the 10th of January 1778, in his 71st year, leaving a widow, with three daughters, besides the son just mentioned.

In stature, Linnæus was rather below the middle size. He was of a stout make; he stooped a little in walking, a habit which it was thought he had contracted from his constant practice of looking downward in search of minute plants or insects. His head was proportionally large, and elevated backwards; his eyes were grey, of small size, but sparkling and penetrating; his sight was very quick.

Count Tessin had a fine silver medal struck in honour of Linnæus, having on one side his bust or portrait, and on the other three crowns, with ornaments emblematical of the three kingdoms of nature. On these the sun is represented as casting his rays, and the inscription is simply, *Illustrat.* A gold medal, containing his portrait, by Lynnberger, was struck by order of the king of Sweden; on the reverse of this appears Cybele, decorated with appropriate attributes of the three kingdoms of nature, and the legend, "*Deam luctus angit amissi.*" In this country, similar honours were paid to his memory. A medallion was prepared by Wedgwood and Bentley of London, in which the profile of Linnæus is in white, on a blue ground, and there is a sprig of the Linnæa borealis on his breast. The Boydells, it may also be mentioned, published a fine engraving of his portrait, taken from an original picture in the collection of Sir Joseph Banks.

Linnæus was destitute of musical ear, insomuch that the finest concert not only gave him no delight, but absolutely annoyed him. He was, however, so far attached to the belles lettres, that he used often to recite passages from the Roman poets, especially Virgil. He wrote and spoke Latin fluently; and the style of his miscellaneous works is generally easy, and often elegant. That his epistolary style is sometimes careless, or even inaccurate, it were needless to attempt to disguise. The descriptive and technical language which he invented or new modelled, has been very generally admired, especially for its expressive brevity and uncommon perspicuity, qualities in which he is not surpassed by Pliny. The sound principles on which he proceeded in this difficult task are excellently unfolded in the *Philosophia Botanica*. Rousseau went so far as to say, that if Cicero had described plants, he would have written like Linnæus. He understood German, French, and Dutch, tolerably well, but had no turn for cultivating a correct knowledge of modern languages. His Swedish writings are said to be among the best models of composition in that language. In his youth, and while he continued in the vigour of life, his memory was wonderfully retentive; but it early began to decay, and it had greatly failed some years before his death.

In domestic arrangements, Linnæus was a pattern of regularity and activity. In summer he slept only five or six hours, retiring to rest at ten at night, and entering his study before four in the morning. In the winter season, he indulged in a little more repose, generally from nine in the evening till six in the morning. It was an invariable rule with him to cease from his investigations, and lay aside his pen, whenever he felt the approaches of lassitude. He was fond of spending the evening in innocent hilarity; he liked a joke, and often did he set the social circle in a roar of laughter, in which he did not scruple heartily to join. The household economy he entrusted wholly to his wife, who, however, did not fulfil the expectations he had formed of her, and for many years did not tend to increase his felicity: her education had been much neglected, and she was naturally of a domineering selfish temper. His house was neatly furnished; and though he was not disinclined to good living, the hardships he had endured in his youth, made him habitually averse to any appearance of profusion. In regard to money, he was far from being of a niggardly disposition, uniformly refusing the fees that were tendered to him, when he had the least reason to suspect that the student was not well provided. His dress was always plain, sometimes careless. He was of a warm temperament; but as his heart was full of probity and of kindly affections, his displeasure was never lasting. He was placable even to his most determined literary opponents. The testimony of the Chevalier Murray to this excellent trait of his character, is quite unequivocal and decisive. The distinguished Haller was the most eminent man who could be numbered among his opposers; but he ultimately proved also the most liberal. In writing to Haller, Linnæus said, "You only and Dillenius I could wish never to have reason to disapprove, for you and he have studied the same book of Nature with me. The opinion of book-learned botanists I value little." It was to be regretted, therefore, that the freedom of Linnæus's critical remarks should have given offence to this distinguished man. He seems to have felt confidence in the uprightness of his own intentions, and to have trusted, that, the only object of botanists being the discovery of truth, and their pursuits being of a pure and peaceable nature, he might use a degree of freedom in correspondence, which, in other cases, would be regarded as hostile criticism.

His mind was deeply impressed with a sense of religion. In his various works, he omits no opportunity of making known his sentiments; and Stoever informs us, that when, in his lectures and excursions, he found occasion to expatiate on the wisdom and goodness of the Creator, as manifested in the structure of his works, and in the admirable provisions for their support and continuance, his breast seemed to glow, and he became truly eloquent. Over the door of his lecture-hall he had inscribed, "Innocui vivite, Numen adest." He was fond of fame; ambitious especially to appear as the prince of botany, and to deserve that high character. But this was a justifiable, if not a praiseworthy feeling; for what honourable mind is destitute of the desire of distinction, or what is to be hoped where this passion has not its influence?

In the summer of 1778, Dr. Hope, professor of botany at Edinburgh, opened his course of lectures with a discourse in honour of Linnæus. Condorcet read an eloge at a sitting of the Academy of Sciences, and Vicq d'Azyr another at a meeting of the Medical Society of Paris. These French discourses have been published; but Dr. Hope's never appeared. This last Professor was a sincere admirer: in the following year, he erected in the Physic Garden at Edinburgh a monument, with the simple inscription, "Linnæo posuit Jo. Hope." In various other botanic gardens, busts and monuments commemorate the renown of Linnæus. Perhaps the most tasteful of these is to be seen in the public garden of Ghent, overhung by a picturesque weeping willow. In the Cathedral Church of Upsal, a magnificent tomb has been raised to his memory at the public expence.

In 1788, a society of naturalists was formed at London, by the exertions and under the patronage of Dr. Smith, author of the *Flora Britannica*, and which took the name of the *Linnean Society*. This society has risen to eminence, and will doubtless prove one of the most signal and durable monuments to the memory of Linnæus. Its Transactions have now (1818) reached the twelfth volume in quarto, and Dr. (now Sir James Edward) Smith is still at its head.

The younger Linnæus, as already mentioned, succeeded his father, and gave earnest that he would fully maintain the high character of the name. In 1781 he visited England, and resided for some time at the hospitable mansion of Sir Joseph Banks. After prosecuting his travels for about two years, he returned home in 1783, with every promise and prospect of a long and honourable career; but, only a few months afterwards, he was unfortunately attacked with fever, and prematurely cut off, having survived his father little more than five years.

Upon occasion of this melancholy event, the Linnæan collection became the property of his mother and sisters. The jealous fears of these narrow minded persons, who dreaded its appropriation at an undervalue by the University of Upsal, occasioned the loss to Sweden of this unrivalled collection. It was privately offered to Sir Joseph Banks, at the price of 1000 guineas; he being justly considered as the most liberal patron of natural history in Europe, and this sum being the highest that their imagination could suggest as its value. Dr. Smith, already mentioned, had recently before taken his degree at Edinburgh, where he had sedulously cultivated a taste for botany: The Doctor chancing to be at the house of Sir Joseph Banks when the offer of the Linnæan collection arrived, and Sir Joseph intending to decline the offer, it was immediately transferred to him, and soon after accepted. The king of Sweden happened to be absent from his dominions during this transaction. On his return to Stockholm, hearing that the collection had just been shipped off for England, and rightly regarding this as a national loss and disgrace, he dispatched a swift sailing war vessel to bring it back. The most signal chace that ever occurred in naval history thus took place; but the patriotic zeal of the king was unavailing; the merchantman gained the Thames, and the whole collection of the illustrious Swede, consisting not only of his grand herbarium, but of all his books and manuscripts, was landed in safety at London, in twenty six great boxes. It must be a consolation to the government and people of Sweden to know, that if the Linnæan collection was to leave their country, it could not possibly have fallen into better hands. This fact is admitted by the universal assent of the botanists of Europe.

See *Life of Linnæus*, by D. H. Stoever; Bäck *Oration before the Academy of Sciences of Stockholm*; Fabricius *of Kiel, in Germ. Museum*, 1780; *Oeuvres de* Vicq d'Azyr, vol. i. *Eloges historiques*, LINNE; *Histoire de l'Academie*, 1781, *Eloge de M. de Linné par* Condorcet; Coxe's *Travels in Russia, Sweden*, &c. vol. iv. *Sketch of the Life of Linnæus*; Pulteney's *General View of the Writings of Linnæus*, &c. (P. N.)

LINZ is a town of Austria, situated upon the Danube. It is large and well built, consisting of a single street, and some annexed suburbs. The principal objects of interest are, its large cathedral, with a fine organ; the chateau of residence, a large and magnificent building; and the library of Lamberg. There is a pleasant prospect from the garden of the convent of Mariahilf. There is here a manufacture of porcelain, and the trade of the town is considerable. Population 9000. East Long 14° 16′ 45″, North Lat. 48° 18′ 54.″

LION. See MAZOLOGY.

LIPARI is the name of the largest of a group of islands in the Mediterranean, called the Æolian or Lipari Islands. It is 19½ Italian miles in circumference. The general aspect of the island is that of an accumulation of dreadful precipices and rugged cliffs, interspersed with a few flat places and declivities, which the inhabitants have cultivated with great labour. If we conceive the island divided into four parts, about 2½ of these are cultivated, and the remainder barren or overgrown with woods. The barren tracts are, however, patiently converted into fertile fields by the increasing population of the island. The principal productions of Lipari are cotton, pulse, olives, and grapes of several kinds. From one kind of grapes is manufactured the common wine of the island, of which 2000 or 3000 barrels are annually exported. Other two kinds of grapes, which are dried, are called the Passole and Passolina. Of the last, which is also called the Corinthian grape, they sell 10,000 barrels annually, and of the other about 12,000. The celebrated Malmsey of Lipari is made from a fourth kind of grape, which is very scarce, and does not supply more than 2000 barrels. The vintage takes place in September.

The animals of Lipari are very few in number. The oxen and cows which are slaughtered here are brought from Sicily. The country produces only rabbits. The partridge, the green-finch, sparrow, gold-finch, horn owl, and raven, are among the stationary birds: Those which migrate are, the sea gulls, the cormorants, the turtle-dove, the quail, and several kinds of swallows.

The principal mountain in the island is Monte San Angelo, situated to the north of the city of Lipari. There is a circular plain on its summit, encircled with eminences shelving inwards, which Dolomieu supposed to be the remains of an ancient crater. The Monte delle Guardia, which looks towards the south, is nearly of the same height. The mountain of Campo Bianco, or the White Field, is three miles distant from the haven of Lipari. It is a prodigious aggregation of beds of white pumice, rising to the height of a quarter of a mile, and extending about half a mile in breadth. The Monte della Castagna, about four miles in circumference, rises beyond Campo Bianco, and is entirely composed of enamels and glasses. Excepting a few lichens, there is not a living vegetable on the whole of the mountain.

The city of Lipari, which extends along the shore in the form of an amphitheatre, with a chain of mountains rising behind it, is erected on an immense rock of lava, rising perpendicularly from the sea. This lava has for its base feldspar, is of a fine compact grain and scaly fracture, dry to the touch, and gives sparks of fire with steel. It is joined to large masses of glass. The town consists of narrow alleys and streets. The castle, encircled with a wall, has a few cannon and a small garrison. The principal buildings are the bishop's palace, the cathedral, and the governor's house. The cathedral contains very valuable sacred utensils, a great deal of plate, and a number of silver images; among which is the statue of St. Bartholomew, their patron saint. This treasure is said to amount in value to about 19,000*l.* Sterling. The celebrated stoves, or dry baths, of St. Calogero, lie about four miles west of Lipari. The stoves, which terminate a descent of about 200 feet in length, form a group of four or five caves, each of which has an opening at the bottom, through which the warm and humid vapours enter, and another at the top, by which they pass out. In one of them the thermometer stood only at $48\frac{2}{3}$°. They are now almost deserted, and retain only their name.

This island carries on a little commerce. The mariners purchase immensely at the fair of Sinigaglio, linens, muslins, veils, and other commodities; and sell them at Messina, Catania, Palermo, and other towns in Sicily. The fishing here is very unproductive. They fish for coral in June and July.

Lipari is under the charge of a military and civil governor, a criminal judge, a fiscal, and a civil judge. The ecclesiastical establishment consists of a bishop, 17 canons of the first order, and 14 of the second.

The other islands to which the general name of Lipari is attached, are Alicuda, Felicuda, Volcano, Stromboli, Basiluzzo, an island about two miles in circuit, with only two cottages, Lisca-Bianca, Bottero, Datollo, Panana, Saline, and Ustica, a rock containing a fort and a few inhabitants. See Spallanzani's *Travels in the Two Sicilies*: and the articles ALICUDA, FELICUDA, and STROMBOLI.

LIQUIDS. See CHEMISTRY.

LIQUORICE. See MATERIA MEDICA, under *Glycyrrhiza.*

LIRIA is an ancient town of Spain, in the province of Valencia. It is the *Edera* of the Carthaginians, and the *Edeta* and *Laurona* of the Romans. It contains some Roman monuments, but particularly an inscription found in 1759, in one of the channels of a fountain, and placed at the door of the Abbey de la Cure. The town stands between two small hills, and has a well built church with three stories of architecture, two chapels of ease, and two convents of Trinitarian and Franciscan monks. Population 6500. See Laborde's *View of Spain*, vol. i. p 260.

LISBON, the capital city of Portugal, is situated in 38° 42′ 18″ of N. Lat. and 9° 7′ 33″ of W. Long. It stands on the north bank of the Tagus, about ten miles from the mouth of the river, and presents a very magnificent and beautiful appearance, as it gradually ascends upon its numerous hills from the verge of the water. It is sheltered on the north-west by a ridge of mountains, but opens towards the south-east; and commands a full prospect of the river, and of the country of Alentejo on the opposite side.

The origin of this city is involved in more than usual obscurity, and has been ascribed to the Grecian Ulysses, from whom its name Olissipa, or Olisipona, is imagined to have been derived. The first inhabitants, according to Pliny, were the ancient Turtuleans, and are supposed to have fallen under the power of Rome after the destruction of Carthage. From various inscriptions found in the city, it appears to have been taken possession of by Julius Cæsar, and to have been called by him Felicitas Juliana. By the Moors, into whose hands it fell with the rest of the peninsula in 716, its name was changed into Lisiboa, as a sound more congenial to their language than its former appellation. In 798, it was reduced by Alphonso the Chaste, King of Gallicia and Asturia; but it passed alternately from the Moors to the Christians, till the former became tributary to Alphonso VI. of Castile, in 1093. Having revolted under Alphonso Henrique, the first Christian king of Portugal, that prince, after many fruitless attempts to reduce the city, received an unexpected reinforcement by the landing of about 14,000 English, French, and Flemish crusaders under William Long Espé (who was destined for the Holy Land, but had entered the Tagus for supplies to their fleet,) and with their assistance he succeeded, after a long and bloody siege of five months, in gaining possession of the capital. Its history becomes henceforward involved in that of Portugal, and the only memorable event which requires to be specified in its separate annals as a city, is its almost entire destruction by an earthquake, on the 1st of November, 1755. At that period, it was about six miles in length, surrounded by a single wall, on which were 77 antique towers of inconsiderable strength, 26 gates on the side towards the river, and 17 towards the land.

It contained two elegant palaces, several magnificent churches, a strong castle commanding the town, 50 colleges and convents, a number of handsome squares, and 150,000 inhabitants. The houses of the higher classes were of of stone, and made a good appearance; but those of the citizens were generally mean, and the streets narrow and dirty.

On November 1st, 1755, a great part of the city was laid in ruins, by one of the most fatal earthquakes ever experienced, which took place about 40 minutes past nine o'clock in the morning, without the slightest previous symptoms of its approach. The shock was short, but violent, and was instantly followed by the fall of every church and convent, almost all the large public buildings, and above the fourth part of the dwelling-houses. Within about two hours after the shock, fires broke out in different quarters, and raged with such violence for the space of nearly three days, that the whole city was completely desolated. The tide also suddenly rose about 40 feet, overflowing many of the lower streets, and occasioning great damage among the shipping. All this took place on a holy-day, when the churches and convents were full of people, of whom very few escaped. About 800 were buried in the ruins of the city prison; 1200 in the general hospital; and 400 in several of the convents. A fine stone quay, to which about 3000 people had fled for security, was turned bottom upmost, and not an individual saved of those who stood upon it. The total number of lives lost in the whole city is computed by some at 30,000, and by others at 60,000.

The length of the town, in its present state, is computed by the Portugese at two leages; but its breadth is very various, sometimes not exceeding one street, and never more than half a league. It is quite open on all sides, having neither walls nor gates, nor any fortifications, except a small castle in the middle of the town, and several batteries on the river. The ground on which it stands is very hilly, which renders some of the streets so steep, that it is a considerable labour to walk along them. The Portuguese are fond of representing their capital as standing, like ancient Rome, on seven hills; but intelligent modern travellers consider it as placed upon three principal rising grounds. The first hill begins at the bridge of Alcantara, forming the western limit of the town, and extending to the street of St. Benedict. This is the highest part of Lisbon, and is celebrated for its salubrious air; but the heavy rains rushing down the steep streets frequently render them impassable, and have been known to carry away both men and horses in the torrents. As the shocks of the fatal earthquake were felt less severely on this hill than in other quarters, it is on that account, as well as its wholesome air, chosen particularly by foreigners as their place of residence, and many handsome houses are erected in various parts of it; but the streets are very irregularly built, ill paved, full of miserable houses, interspersed with gardens, and even corn fields amidst the buildings. On this height is the Protestant burying ground, planted round with cypress and judas trees, and containing numerous monuments of the illustrious dead. The second hill is only a continuation of the first, from which it is separated by a valley of moderate depth. Most of the streets are here extremely narrow, crooked, and covered with heaps of filth; but at the foot of the eastern side, (where the earthquake did great damage, and where many ruins are still visible,) there are several handsome recently built houses. This hill rises to a considerable height, and becomes very steep towards the next valley, in which is seen the best part of the town, presenting a singularly striking view from the eminence. This valley, which adjoins to the second height, is of considerable length and breadth, and forms the broadest part of Lisbon. The buildings here having been totally destroyed by the earthquake of 1755, the present streets are structures of modern date, and disposed in better order. At the bank of the river, where the valley begins, the quay is well finished; and adjoining to it is a large handsome square, 610 by 550, called the Praça do Commercio, formerly the terrace and parade of the royal palace. From this square, three principal streets, straight and broad, lead to the Praça do Rocio, where the great palace of the Inquisition is situated. The third hill begins with an eminence, on which is the castle of Lisbon, (a small fort, capable of making little resistance,) and continues, with some intervening plains, to the eastern extremity of the city. This is the oldest part of the town, full of narrow and ill-paved streets, and lofty houses of many stories. Following the river to the eastward, small houses and villages succeed each other with little interruption; and, on the westward, the village of Belem, a considerable market town, inhabited by many persons of property, is so near to the city, that the separation is scarcely perceptible, and continued suburbs unite the two towns. On the north side are lofty hills, which preclude all view to the city, till the traveller suddenly arrives in the streets. On the south, the Tagus runs close along the foundations of the houses, being about one league in breadth opposite the western part of the town; but opening to the width of from two to three leagues towards the eastern extremity.

No models of architecture are to be found among the private houses or public buildings of Lisbon, though there are many which may be accounted handsome; nor is the interior disposition of the apartments, or even the entrances, deserving of any commendation. Most of the new streets are spacious, regular, well-paved, and provided with convenient foot-paths. The houses are lofty, uniform, and strongly built, in a manner rather singular. The carpenter first raises the skeleton of frame work, and the mason then fills up the interstices with rublestone and brick; in which plan there is supposed to be this advantage, that the connection of the walls with the wooden work contributes to resist those slight concussions of earthquakes with which the city is so frequently visited. The first story of each dwelling-house, if not used as a shop, is employed as a magazine for merchandize, and sometimes as coach-house and stable. In a house of four stories, the attic is counted the pleasantest floor, and is frequently furnished with a balcony, ornamented with gilt iron rails, and provided with silk or linen awnings for the accommodation of the ladies, who sit there on cushions in hot weather, reading, sewing, or amusing themselves. Coolness and ventilation, rather than warmth, are consulted in the distribution of the apartments. Grates and chimney-pieces are almost unknown, and a warm cloak in winter is the usual substitute for a fire.

The public edifices most deserving of notice, are the royal exchange and custom-house, forming the north wing of the Praça do Commercio, which are suitably adapted to their object in point of strength and convenience; the patriarchal church, situated on an eminence at the north-east side of the city, which is full of relics and precious ornaments, but of which the chief curiosities are the cross and nine candelabri of the king's chapel, the former of silver gilt, and twelve feet high, the latter also of silver gilt, covered with diamonds and various groups in demi-relief; the Loretto church, built by the Pope's nuncio about the end of last century, and designed in Italy, but possessing little architectural excellence; the church of St. Roque, formerly belonging to the Jesuits, a neat building, containing some good pictures in fresco on its walls and ceilings, with several fine pieces of mosaic, but most distinguished for a beautiful chapel dedicated to John the Baptist, richly ornamented with a variety of precious stones. The new church built by the late Queen of Portugal, the largest and most magnificient edifice raised in Lisbon since the earthquake of 1755, is built in the form of a cross, with beautiful white limestone, which gives it a cheerful appearance, but it is too much loaded with ornament, and is remarkable chiefly for its finely executed dome. The royal monastery of Belem, founded by Prince Emanuel in 1499, the architecture of which is compounded of the Norman Gothic and Arabesque styles, and particularly noted for the variety of its pillars, every one of which is executed in a different manner; two neat new churches in the same town, the monastery of Bomsuccesso, founded in 1626, and the Irish convent or college of the Dominican order, founded in 1659. But the most remarkable structure of Lisbon is the magnificent aqueduct close to the north side of the town, founded by John V. in 1713: a work not inferior in magnitude to any of the aqueducts of antiquity, and worthy to be compared with the most magnificent monuments of modern art. The whole length of the aqueduct is 2400 feet, part of it passing under ground through a tunnel of stone, and part of it crossing a deep valley by means of arches, of which the largest is 230 feet high, and 107 broad.

Among the curiosities of Lisbon, which are very few in number, may be mentioned the equestrian statue of Joseph I. in bronze, which stands in the centre of the Praça do Commercio, on a pedestal of stone adorned with various symbols. It was cast in one piece by Bartholomew de Costa, from a model by Machado de Castro; and though the figures are stiff, and the symbols overloaded, yet the whole is accounted a production of considerable merit. The cannon of Diu, about twenty feet in length, with a proportionable calibre, taken from the king of Cambay at the siege of Diu or Dio, and sent to Portugal about the year 1539, bears a curious Arabic inscription, and is preserved as a trophy in the armory.

The principal charitable institutions of Lisbon are, the Foundling Hospital, which in 1789 received 1279 children; the Royal Hospital of St. Joseph, for the infirm and diseased of both sexes, and of all nations, which admitted in the same year about 11,000 patients; and the Brotherhood of the Misericordia, who perform various acts of charity, such as visiting the jails and hospitals with suitable relief to the prisoners or patients, educating, and apprenticing, and portioning poor children, and administering to the afflicted of every description and country. The literary institutions of Lisbon, though not in a flourishing state, are more numerous and reputable than has generally been imagined. The Academy of Sciences, founded by the late queen of Portugal, is the most important, and has published 6 volumes of *Memorias de Litteratura Portugueza*, consisting chiefly of papers on the history and laws of the kingdom, three parts of memorias, economics, &c. A Geographical Academy was instituted in 1799, and has prepared a new map of the country, which was greatly needed. The College of Nobles is a handsome building, founded in 1761; the Academia real das gardas Marinhas, founded in 1782, the Academia real de Marinha, in 1779, and Academia real da Fortificatio, in 1790, have also their professors, but are in a lingering condition; and, though the means are not wanting, the taste for knowledge is not general. There are several public libraries, which, though by no means of the first class, are not so despicable as they have been represented. One in the Praça do Commercio contains many important works; one in the Benedictine Monastery of Nossa Senhora de Jesus has a complete collection of Spanish and Portugese literature, besides several French and Italian writings; and one in the Monastery of San Vincente de Fora is provided with the smallest Portugese productions. The royal museum at Ajuda, though small and ill-stocked, is worthy of being visited, and contains several curiosities from Brazil, particularly a piece of copper ore above three feet long, two broad, and two thick, weighing 2616 pounds; and a piece of elastic sand-stone, covered with crystals of calcareous spar. Behind this museum is a small chemical laboratory and a botanic garden, finely situated, and neatly kept. The museum of the Marquis of Angeja contains, among other specimens, one of diamonds from Brazil embedded in argillaceous iron-stone; and another in the monastery of S. N. de Jesus consists chiefly of shells.

The places of public amusement are, the Italian opera, said to be well supported; a theatre, which is small, and not much attended by the higher classes; an assembly room chiefly for foreigners, as the Portuguese are no lovers of dancing; the circus for bull-fights, chiefly attended by the middle and lower classes, and in summer open almost every Sunday afternoon; the public walks near the Rocio, planned by the Marquis of Pombal, elegantly planted with trees and shrubberies, but not much frequented; and one tolerable coffee-house visited by the higher classes, provided with every thing that can be required.

The population of Lisbon cannot be correctly ascertained, as it is only of the houses that a census is taken; but including the suburb and the village of Belem, the number of inhabitants is confidently estimated at more than 300,000, exclusive of the military.

The police of this city is miserably defective in every respect. The filth lies in heaps even in the most frequented streets, so that it requires considerable care to avoid sinking in them, and to escape the effects of the carts and horses splashing in the mud. There is a great want of common sewers, water-pipes, and necessaries; and all kinds of dirty collections are apt to be poured from the windows at night, frequently with little warning to the passengers. From want of lamps also, and from the early shutting of the windows, the streets are extremely dark, and filled, at the same time, with hungry dogs and desperate robbers. As all kinds of idle people are permitted, without any impediment, to pour into the city from the provinces, the number of beggars and vagrants is immense; and of these a very great proportion are negroes and creoles. The porters, water-carriers, and most of ths servants, come from the Spanish province of Gallicia; and are generally denominated Gallegos, even though they may have a different origin.

The appearance of Lisbon is dull and melancholy, as the inhabitants neither walk, nor ride, nor sail, nor form any parties of pleasure. There is little appearance of shew, or of fine equipages, among the wealthy; except the desire of keeping many servants, who are poorly clothed and ill fed. They keep much within the circle of their own families; and spend a great part of the year in their summer residences, or garden houses in the country around the capital; particularly among the mountain retreats of Cintra during the heats of August and September.

The harbour of Lisbon is full of shipping, but its commerce and riches are by no means adequate to what might be expected from its magnificent river, and advantageous situation for trading with both the eastern and western hemispheres. In the year 1789, 892 ships entered the port of Lisbon, of which 252 were Portuguese, and the remaining 640 were foreign vessels; of this last number one half were from Great Britain and Ireland.

The climate of Lisbon is very salubrious, and sufficiently pleasant to those who are accustomed to it. In January cold and clear weather often prevails; but in February the temperature becomes mild and pleasant. Snow is extremely rare, and scarcely known to the inhabitants, so as to be regarded as a kind of prodigy when it happens to fall. Ice appears in the fountains before sun-rise, but is quickly thawed by the heat of the day. In consequence of the increasing heat of the sun in February, and the consequent chills of the evening, severe catarrhs are common in that month. After the equinox heavy rains take place, accompanied with violent storms; and from this period to June is the most changeable season of the year, the weather being alternately rainy and cool, or hot and dry. From midsummer to the middle of September rain is extremely uncommon, and every vegetable production becomes completely parched. The heat, which during this period is incessant, though much moderated by the sea-breezes, very commonly rises to 96° of Fahrenheit, and has been known to reach 104°. About the end of September the first rains arrive; and in October, which may be counted the spring in point of vegetation, the young grass and new leaves appear. In November and December heavy rains, with frequent storms, are experienced; and the little streams are every where converted into dangerous torrents. Earthquakes occur only between October and April, and are generally observed to accompany the first rains which follow a tract of dry, sultry weather. The grain is usually in ear in the month of March, and the harvest takes place in May.

The inhabitants of Lisbon subsist chiefly on butcher meat and fish, particularly pilchards, without using many vegetables. Their beef and pork are good, but their mutton inferior. The bread is generally bad; and, in place of it, the common people eat great quantities of lupins, or rice, the latter article being imported abundantly from Brazil. Small beans, brocoli, cauli-flower, lettuce, and gourds, are very common. The best fruits are oranges, grapes, melons, figs, and chesnuts. Apples and pears are good, but scarce; plumbs, cherries, and peaches, are both scarce and bad. The environs of Lisbon, particularly on the east and north sides, to a considerable distance from the town, are covered with large gardens, surrounded with very high walls, between which the road leads sometimes for leagues, without any other object being visible. These enclosures are called Quintas; and are as much parks as gardens, containing generally plantations of orange and olive trees, sometimes even corn fields and vineyards, with a considerable villa or summer house. Towards the west the country is not so well cultivated, and there are several naked rocky hills; but in some spots these are extremely fertile, affording the best pastures to the city, and a great variety of natural plants for the botanist. See Link's *Travels in Portugal.* Murphy's *Travels in Portugal. Phil. Trans. of London*, vol. xlix. (of Abridg. vol. x) (*q*)

LISBURN is a neat post and borough town of Ireland, in the county of Antrim, and province of Ulster. The principal buildings are, the Church, the Presbyterian meeting house, the Quaker's meeting house, which is a small neat building, the Methodist chapel, which is of considerable size, a neat Roman Catholic chapel, and the Market house. A fine spire of hewn stone was some years ago added to the church, and a cupola and steeple on the Market house. There is also a French chapel here, with an endowment of 60*l.* per annum. As Lisburn is only 7 miles from Belfast, it cannot be expected to be a place of much trade; but a good deal of business is done in the town. A great deal of linen is brought to it on the market days, and it is celebrated for seed oats of the best quality. There is here a vitriol manufactory, where muriatic acid and glauber salts are made, and also a manufactory of Damask. The Quakers established in 1774 a boarding school in Lisburn, for the education of children of all sects. In 1794 it was confined to Quakers. Twenty boys, and twenty-five girls, are boarded, clothed, and educated, at the rate of 3*l.* per annum, and the poor are admitted gratis. Lisburn sends a member to parliament, and belongs to the Marquis of Hertford. Between Lisburn and Belfast, along the borders of the counties of Antrim and Down, the scenery is very grand and striking. The land is in general cultivated and interspersed with plantations and villas, belonging to the wealthy merchants of Belfast. Population in 1813, 4785.

LISKEARD, or LESKEARD, a borough and market town of England, in the county of Cornwall, and one of the stannaries for the coinage of tin. It is situated partly on rocky hills, and partly in a valley, and, from the irregularity of the ground, the streets and houses are grouped with singular irregularity, the foundations of some of the buildings being on a level with the chimnies of others. The Church dedicated to St. Martin stands on the east side of the ascent to the town. It is kept in good repair, and consists of three spacious aisles; the tower on the west end of it, with the date 1627, is chiefly built of granite. The south side of it is adorned with pinnacles and battlements of granite, and there are three gothic arches over the porch. The town hall and market-house, which is a handsome structure, supported by granite columns, was erected in 1707, by Mr. Dolben, the representative of the burgh. It has a turret at the top, and a clock with four dials. The clothing trade flourished here before the late war; but the principal business now is tanning and the making of boots, shoes, and other leather ware. The government of the town is vested in a mayor, eight capital burgesses, and 15 assistants. The right of election of a member of Parliament is vested in the corporation and the sworn free burgesses. The mouldering foundations of a castle appear on an eminence to the north of the town. There are many tin mines on the hills of North Liskeard, the metal from which is cast into blocks at the blowing houses, and sent to be coined in this borough. There is an excellent free school here, and a good conduit for the supply of water. The population of the burgh, in 1811, was 361 houses, 402 parishes, 209 of which were employed in trade and manufactures; and 1975 inhabitants. North Lat. 50° 26′ 55″, and West Long. 4° 41′ 30″. See Polywhele's *Cornwall, and the Beauties of England and Wales*, vol. ii. p. 383.

LISMORE, or "the Great Garden," is the name of one of the Hebrides or Western Isles of Scotland, in the county of Argyle, and situated at the mouth of the great arm of the sea called Loch Linnhe. It is a low green island, about 10 miles long, and about 13½ miles broad at an average. The superficial extent is 8000 acres. It extends from south-west to north-east, and is only 3½ miles from Dowart Point, on the island of Mull. As the whole island is a mass of limestone, the soil formed by the decomposition of that rock is extremely fertile, and is, besides, here and there richly manured with marl, which is found to the depth of 8 to 18 feet at the bottom of every marsh or lake. "There is to be seen", says Mr Macdonald, "on the face of a limestone rock seven or eight feet above the surface of the ground, and beyond the reach of tides at present, a seam 12 or 15 inches broad, of a concretion composed of all the varieties of shells to be found on these coasts, with now and then a small mixture of charcoal, as firm, and nearly as solid, as the rock surrounding it, to which it seems to be perfectly united, and of which it makes a part. Water running over the face of the limestone rocks of this island has gradually worn them away, and many grotesque figures are formed by the more solid and remaining parts. The limestone rocks lie all in one direction, in layers above one another, nearly from south-east to north-west. There are seams or spars three or four feet broad, of remarkably hard flinty rocks or stones running across the island at the distance of nearly two miles from one another. These seams appear to run in a direct line with similar ones on the opposite coast of Morven, where there is no limestone." Mr. Pennant found here the scull of an ox, of much larger dimensions than any now living in Great Britain. Roe and deer's horns of immense size are dug out of the mosses. The pith of one of the ox horns was 12½ inches in circuit at the root.

The principal crops raised in Lismore are, oats, barley, beans, flax, potatoes, a few green crops and grasses. Mr. Macdonald remarks, "that a great proportion of the arable land is under beans, a circumstance uncommon in the Hebrides, and they are found to answer pretty well twice or thrice successively in the same fields. After beans, two crops of oats are taken, and the potatoes are planted in drills, and not unskilfully managed. Eight bolls of beans, and 16 of potatoes is a good crop, and these have of late averaged a value of from 10*l.* to 12*l.* Sterling on the best parts of the island."

A considerable number of small cattle are reared in the island, and about 100 head are exported annually. The horses are harnessed when they are two or three years old, and are very short lived. There are three small lochs in the island, two of which contain excellent trout, and the third eels:—The limeworks here have been carried on by a company. A barrel of lime costs only 10d. at the place of shipping. Lismore was once the seat of the bishop of Argyle, and the remains of the cathedral of the bishop's palace are still to be seen: the chancel of the former constitutes the Romish church. There are several fortified camps in different parts of the island, and there is a Danish fort surrounded by a deep fosse, in tolerable preservation. On the south side of Lismore is a small island, with a curious rock covered with ivy, which resembles the remains of an old house. The valued rent of the island is 268*l.* 13*s.* and the population is 1323. See Pennant's *Tour in Scotland*, and Macdonald's *Account of the Hebrides*, p. 733.

LISMORE is the name of a post town of Ireland, in the county of Waterford. It is situated on the river Blackwater, which is crossed by a fine bridge, (one of whose arches is 190 feet span) erected by the Duke of Devonshire. The principal public buildings are, the castle, a neat court-house, and the church. The castle, which appears to have been a place of strength, stands on a rock which rises almost perpendicularly to an enormous height, and is covered with picturesque trees, which add greatly to the effect. This castle was built by King John in 1185, on the ruins of the abbey of St. Carthagh, and was once the property and residence of Sir Walter Raleigh. The entrance to the castle is through an ancient avenue of trees, and opposite to the entrance is a modern Doric portico of Bath stone, designed by Inigo Jones. The great philosopher, Robert Boyle, was born in it. The church, which is spacious and handsome, serves both as the cathedral and as a parish church. There are excellent salmon rivers at Lismore, which yield a considerable profit. "Before you approach the town of Lismore," says Mr. Wakefield, "you fall into a beautiful glen, which proceeds in a winding direction, the sides of the mountains by which it is formed being clothed with oak and ash for the distance of two miles. A stream of considerable size, which discharges itself into the Blackwater at Lismore, runs through it, and forms no small addition to its beauties." *Statistical Account of Ireland*, vol. i. p. 76.

LISSA, anciently *Issa*, is an island in the Adriatic, and belonging to Dalmatia. It is very mountainous, and thinly inhabited, and is about 30 miles in circumference. Its principal productions are wine, fruits, and honey. Its wine is excellent, and is remarkable for being the strongest that is made, being at the head of the list of wines examined by Mr. Brande. There is a considerable fishing of sardines and anchovies. Its former capital, called Lissa, appears in ruins above the harbour, and near a village of the same name. The town of Comisa is well built and populous, and is situated near the sea, on the east side of the island, where the ruins of the ancient city of Meo are still to be seen. Lissa was anciently in alliance with Rome, and aided the Roman republic with twenty armed vessels against Philip king of Macedon. See Cæsar, *Comment.* lib. iv. and *Tit. Liv. Dec.* 4. liv. 1. East Long. 16° 18′, and North Lat. 43° 25′.

LISTON's SCALE of musical intervals. In our article, ENHARMONIC *Organ*, we have given a pretty full account of the important improvements in the theory and practice of organ music, which were a few years ago made by the Rev. Henry Liston; and in the article, *Perfect* HARMONY, have referred to this place for giving the scale of 59 notes in each octave, besides its repetition c, which are practically introduced upon these improved instruments, as follows, viz.

1	2	3			4	Literals, or Notes.	Ratios.	Values in Farey's Notation $\Sigma + f + m$.			Numeral Values.
c	$\frac{1}{2}$	612	12	53	VIII, or octave	C	$\frac{1}{1}$	1	0	1	1 or unison
B′♯	$\frac{1024}{2025}$	602	12	52	Extreme ♯ VII′						
cˋ	$\frac{81}{100}$	602	12	52	VIII′	C	$\frac{80}{81}$	11	1	1	1′
B♯	$\frac{64}{125}$	591	12	51	Extreme ♯ VII						
c′♭	$\frac{25}{48}$	576	11	50	8′	C′♯	$\frac{24}{25}$	36	1	3	1ˋ
B′	$\frac{128}{243}$	566	11	49	VII′						
c♭	$\frac{135}{250}$	565	11	49	8, or ex.♭VIII	C♯	$\frac{128}{135}$	47	1	4	I, or Ext.♯1
B	$\frac{8}{15}$	555	11	48	VII	D♭	$\frac{15}{16}$	57	1	5	2, or Ext.♭II
						C′♯	$\frac{2048}{2187}$	58	1	5	
Bˋ	$\frac{27}{50}$	544	11	47	VIIˋ	D′♭	$\frac{25}{27}$	68	1	6	2′
						C♯♯	$\frac{1024}{1125}$	83	2	7	Extr.♯♯1
B′♭	$\frac{5}{9}$	519	10	45	7′	Dˋ	$\frac{9}{10}$	93	2	8	IIˋ
						C′♯♯	$\frac{16384}{18225}$	94	2	8	
A′♯	$\frac{2048}{3645}$	509	10	44							
B♭	$\frac{9}{10}$	508	10	44	7, or ex.♭VII.	D	$\frac{8}{9}$	104	2	9	II
♯	$\frac{128}{225}$	498	10	43	Extr.♯VI.						
						D′	$\frac{640}{729}$	115	2	10	II′
Aˋ♯	$\frac{72}{125}$	487	10	42							
B′♭♭	$\frac{125}{216}$	483	9	42							
B♭♭	$\frac{75}{128}$	472	9	41	Ex.♭7, or E♭♭VII	D♯	$\frac{64}{75}$	140	3	12	Extr.♯II
A′	$\frac{16}{27}$	462	9	40	VI′	Eˋ♭	$\frac{27}{32}$	150	3	13	3ˋ
						D′♯	$\frac{1024}{1215}$	151	3	13	
A	$\frac{3}{5}$	451	9	39	VI	E♭	$\frac{5}{6}$	161	3	14	3, or Ext.♭III
						E′♭	$\frac{200}{243}$	172	3	15	3′
A′♭	$\frac{50}{81}$	426	8	37	6′						
A♭	$\frac{5}{8}$	415	8	36	6, or ex.♭VI.	E	$\frac{4}{5}$	197	4	17	III
G′♯	$\frac{256}{405}$	405	8	35		Fˋ♭	$\frac{405}{512}$	207	4	18	
Aˋ♭	$\frac{81}{128}$	404	8	35	6ˋ	E′	$\frac{64}{81}$	208	4	18	III′
G♯	$\frac{16}{25}$	394	8	34	Extr.♯V.	F♭	$\frac{25}{32}$	218	4	19	Extr.♭4
						F′♭	$\frac{125}{162}$	229	4	20	
						Eˋ♯	$\frac{96}{125}$	233	5	20	
G′	$\frac{160}{243}$	369	7	32	V′						
						E♯	$\frac{512}{675}$	244	5	21	Extr.♯III
G	$\frac{2}{3}$	358	7	31	V	F	$\frac{3}{4}$	254	5	22	4, or Ext.♭IV
						E′♯	$\frac{8192}{10935}$	255	5	22	
F♯♯	$\frac{4096}{6075}$	348	7	30							
Gˋ	$\frac{27}{40}$	347	7	30	Vˋ	F′	$\frac{20}{27}$	265	5	23	4′
F♯♯	$\frac{256}{377}$	337	7	29	Ex.♯IV, or E♯♯4						
G′♭	$\frac{25}{36}$	322	6	28	5′	Fˋ♯	$\frac{18}{25}$	290	6	25	IVˋ
F′♯	$\frac{512}{729}$	312	6	27	IV′						
G♭	$\frac{45}{64}$	311	6	27	5, or ex.♭V	F♯	$\frac{32}{45}$	301	6	26	IV, or Ext.♯4

The Listonian scale has been so arranged in the above table, in two parts reversed, as to shew the *complements to the octave* opposite, on the same line, and to distinguish clearly all such notes as have no complement in this scale; of which latter there are 22 instances, indicating a much greater dissimilarity in the two halves of the octave, reckoned upwards from C, and downwards from c, than we could have anticipated before ascertaining the fact by means of this table.

The 22 notes wanting for supplying a complement to every note, are as follows, viz.: In col. 1. cˋ♭, c♭♭, cˋ♭♭, Bˋ♭, Bˋ♭♭, A′, Gˋ♯, A′♭♭, A♭♭, and Aˋ♭♭; and in col. 2, beginning at the bottom, Gˋ♭, G♭♭, Gˋ♭♭, Fˋ, Eˋ, Dˋ♯, Eˋ♭♭, E♭♭, Dˋ♭, D♭♭, and Dˋ♭♭; which addition would increase the number of notes in the octave to 81, or to 82, if the octave note C×c be both included, and in which scale no doubly acuted or doubly graved notes (″ or ˋˋ) will be found.

The top of the second column is, in fact, to be considered as the bottom of this table, which is the reason of the titles to the columns being there placed agreeably to the practice of musicians, in numbering, lettering, and reading of their notes *upwards* instead of downwards.

Mr. Farey, in vol. xlix. p. 362 of the *Philosophical Magazine*, describes his having added a second or acuter octave of notes to that contained in the third column of the above table, and then proceeded to make each of the 3422 different subtractions of each interval from every other larger one; and whence 220 different intervals had resulted, as a complete table of enharmonic intervals within an octave, only 12 of which were found to be without their complements. In a note on p. 363, Mr. Farey informs us, that no two intervals throughout his table were found to have different combinations of f or m, with the same number of Σ's; and whence it appears, that for every purpose of comparing Listonian intervals, the f's and m's may safely be neglected, and the Σ's only (in the first range of col. 3.) may be used, as *artificial commas* (see that article,) without ambiguity or error, in any case. And whence the important advantage may be gained of using *the number of* Σ's, instead of a name for *designating each of the harmonic notes;* and such numbers should be engraven or painted on the pipes of enharmonic organs, instead of the literal marks which are ordinarily used.

In our article INTERVAL, we have mentioned an extension of our table above made by Mr. Farey, according to Mr. Liston's principles of tuning, carried on until each one of the series of 612 artificial commas occurs, and forms thus a scale of as many equal parts (or extremely near to it) in the octave; the literal notation answering to each, of which 612 notes are given in our article referred to. In our article MUSIC, the Listonian scale will be further considered in connection with the general principles and the practice of music. (*ϱ*)

LITERALS, in music, are the first seven letters of the alphabet, applied to designate the seven notes of the scale in the minor mood, or octave, viz. A, B, C, D, E, F, G, and a, (the letter a being an octave to the first A,) as they do also the major mood, by beginning at C, viz. C, D, E, F, G, A, B, and C, these two moods forming indeed but one scale, with a different place of beginning in the different moods. Whenever this scale is required to be extended, or filled up with a larger number of notes, it is done by means of a series of consecutive or following fifths, each of the same magnitude, as C, G, D, A, E, and B, reckoned upwards, and C, F, downwards; or, by joining these into one ascending series, we have F, C, G, D, A, E, B, and f♯, if we reckon or tune upward, or B, E, A, D, G, C, F, and B♭, if we reckon or tune downwards.

This is the case, whether in tuning a system of *perfect* fifths, as in Mr. Liston's extended scale, (see *Phil. Mag.* vol. xlix. p. 455,) or of tempered fifths, in any of the various modes of regularly attempering the scale. In tuning upwards, after f♯, follow c♯, g♯, d♯, a♯, e♯, b♯, and then *f*♯♯, *c*♯♯, &c. so in like manner, in tuning downwards, after B♭, occur E♭, A♭, D♭, G♭, C♭, F♭, and B♭♭, and then E♭♭, A♭♭, &c. to any extent to which the tuning process may be carried. In the article TEMPERED *System*, it is our intention to give a table of theorems, for readily calculating, independently, the values of each literal note, and sharpened and flattened note, in the extended scale of David Loeschman's patent piano-fortes and organs, without deriving each from a connected chain of fifths, as above described. (*ϱ*)

LITERARY PROPERTY, or *Copy-Right*, is the right which an author may be supposed to have in his own original literary compositions; so that no other persons, without his leave, may publish or make profit of the copies. As this right has become of great importance in modern times, and has occasionally been made the subject of very interesting discussion, it may be proper to bring under the view of our readers the substance of the various opinions which have been entertained, and the different laws which have been enacted, relative to this matter.

That every individual, engaged in a lawful occupation, has a right to dispose of the produce, and enjoy the fruits of his labour, is a proposition consistent with the most obvious rules of justice. Accordingly, as Blackstone observes, when a man, by the exertion of his rational powers, has produced an original work, he has clearly a right to dispose of that identical work as he pleases, and any attempt to take it from him, or vary the disposition he has made of it, is an invasion of his right of property. Now, the identity of a literary composition consists entirely in the *sentiments* and the *language;* the same conceptions, clothed in the same words, must necessarily be the same composition: and whatever method be taken of conveying that composition to the ear or the eye of another, by recital, by writing, or by printing any number of copies, or at any period of time, it is always the identical work of the author which is so conveyed; and no other man can have a right to convey or transfer it without his consent, either tacitly or expressly given. This consent may perhaps be tacitly given, when an author permits his work to be published, without any reserve of right, and without stamping on it any marks of authorship. But in case of a bargain for a single impression, or a sale or gift of the copy-right; the reversion is plainly continued in the original proprietor, or the whole property transferred to another.

On the other hand, it has been urged, that, although an author possesses an exclusive right to his manuscript, and all which it contains, before it is printed or published; yet that, from the instant of publication, this right ceases, as being of a nature too subtile and unsubstantial to be protected by the common law, without being guarded by positive statute and special provision.

It may be observed, however, that the question with regard to literary property is of very modern date, and could only arise at a very advanced stage in the progress of the arts and civilization. Before the art of printing was invented, indeed, and while copies of books could only be obtained by the tedious method of transcribing, it is evident that authors could derive but little pecuniary advantage from the sale of their performances. But although there is no doubt that the earliest and best works of antiquity were written and communicated to the world from no prospect of gain, yet we may gather from several passages in Latin authors, that sales of literary copies, for the purposes of recital or multiplication, were not unknown to the Romans, but appear to be as ancient as the times of Terence, Martial, and Statius. In the civil law, however, we find no mention made of any property in the works of the understanding; nor does it appear that their lawyers ever entertained an idea that authors, after publication, could prohibit others from transcribing their compositions.

On the discovery of the art of printing, the first inventors were very desirous to monopolize it; and, therefore, did their utmost to conceal the process. But, in spite of their endeavours, it soon spread; printers multiplied, and interfered with one another, as must always be the case, in a greater or less degree, with persons who are concerned in the same trade. In order to prevent this inconvenience, some of the early printers applied to the Pope, the republic of Venice, and the duke of Florence, to get the sole privilege of printing the books of which they were the first publishers; and this they obtained for a term of years, seldom exceeding fourteen, and often not so long, as appears from the first editions of the classics, to which patents are commonly prefixed. Hence it would appear, that literary property was originally a privilege granted, not to authors, to encourage them to write, but to printers, to induce them to print editions of works which were then in manuscript. But the transition, from the encouragement of printers to that of authors, was natural and obvious; and accordingly, soon after, privileges appear in favour of the author, which are by him commonly assigned to the bookseller, whose name is marked on the title-page.

Upon this footing, therefore, the matter stood throughout Europe: The abstract right does not appear to have been legally recognized; but privileges were granted from favour, and with a view to public expediency.

In Britain there was not, until lately, any final determination of the courts upon the right of authors at the common law. It was decided in the case of *Miller* v. *Taylor*, in ***B. R. Pasch.*** 9 Geo. III. 1760, that, by the common law, authors possessed an exclusive copy right. But afterwards, in the case of *Donaldson* v. *Becket*, which was finally determined by the house of lords, 22d February 1774, it was held that no copy right subsists in authors, after the expiration of the several terms created by the act 8 Ann. c. 19. This statute, which was enacted "for the encouragement of learning, by vesting the copies of printed books in the authors or purchasers of such copies, during the terms therein mentioned,"—declares, that the author and his assigns shall have the sole liberty of printing and reprinting his works for the term of fourteen years, and no longer, and also protects the property by additional penalties and forfeitures: and it farther provides, that if the author be alive at the end of the above mentioned term, the right shall return to him for another term of the same duration.

The statute above referred to,—which destroyed any claim of perpetual copy right that might have existed at common law, and substituted one for a more limited period,—farther directs, that nine copies of each book that shall be printed or published, or reprinted and published with additions, shall be delivered by the printer to the warehouse-keeper of the Company of Stationers, before publication, for the use of the royal library, the libraries of the universities of Oxford and Cambridge, of the four universities of Scotland, of Sion College in London, and of the Faculty of Advocates at Edinburgh. By the act of 41 Geo. III. the same privilege was conferred on the libraries of Trinity College and the King's Inn, Dublin. In the case of *Beckford* v. *Hood*, in 1798, the Court of King's Bench decided, that the omission of the entry at Stationers' Hall only prevented a prosecution for the penalties inflicted by the statutes, but did not hinder recovery of satisfaction for the violation of copy right. The same court determined, in the case of the *University of Cambridge* v. *Bryer*, in 1812, that the eleven copies might be claimed by the public libraries, whether the books had been entered at Stationer's Hall or not. In the following year, however, a variety of petitions were presented to parliament, complaining of the burthen imposed upon publishers by these acts, and claiming redress. These petitions were accordingly referred to a committee of the House of Commons, who made a report upon the subject; and in 1814, another act was passed, which confirmed and extended the provisions of the former statutes. By this statute (54 Geo. III. c. 156,) it was enacted, "that, from and after the passing of this act, the author of any book or books, composed and not printed or published, or which shall hereafter be composed, and be printed and published, and his assignee or assigns, shall have the sole liberty of printing and reprinting such book or books for the full term of twenty-eight years, to commence from the day of first publishing the same; and also, if the author shall be living at the end of that period, for the residue of his natural life." Persons trespassing upon the copy right granted by this act are made liable to a special action upon the case for damages, with double costs of suit, and forfeiture of the books, and of three pence for every sheet thereof, either printed or printing, or published and exposed to sale, contrary to the intent and meaning of the act. The same privileges are declared to extend to books already published, and of which the authors are still living. This act also directed the indiscriminate delivery of one large paper copy of every book, at the time of its entry at Stationers' Hall, to the British Museum, but limited the claim of the other ten libraries to such books as they should demand in writing within twelve months after publication. Complaints, however, still continued to be made of the hardships to which publishers were subjected in consequence of these enactments; and in the report of the committee of the House of Commons, appointed to examine the copy-right acts, which was ordered to be printed in the month of June last, the committee recommend that so much of the act as requires the gratuitious delivery of eleven copies should be repealed, except so far as relates to the British Museum, and that a fixed allowance should be granted in lieu thereof, to the other libraries; or, if it should not be thought expedient to comply with this recommendation, that the number of libraries entitled to claim such delivery should be restricted to five, *viz.* the British Museum, the libraries of Oxford and Cambridge, and of the universities of Edinburgh and Dublin. The committee farther recommend, that books of prints, containing a very small proportion of letter-press, should be exempted from delivery, as also all books in respect of which the claim to copy-right shall be abandoned; and that printers shall not be obliged, as heretofore, to retain one copy of each book printed by them, but that the copy of the Museum be made evidence instead of it. See Maclaurin (lord Dreghorn) *On the origin and progress of Literary Property;* Blackstone's *Comment.* b. ii. ch. 26, § 8; and the several acts of parliament and Reports of Committees of the House of Commons, which have been referred to in this article.

LITHARGE. See CHEMISTRY.

LITHOGRAPHY, from *λιθος, a stone*, and *γραφειν, to write*, is the art of taking impressions from drawings or writings made on stone. It is quite a modern invention, and was first discovered by Aloys Sennefelder, a singer in the theatre of Munich, about the year 1800. Soon after its discovery, Sennefelder obtained from the Elector of Bavaria the exclusive privilege of practising this art within his dominions for thirteen years. He afterwards carried his invention to Vienna in 1803, where he obtained a similar privilege for ten years from the emperor of Austria. His residence in Vienna, however, was of short duration, and the establishment which he had here formed made little progress in the art, but was confined chiefly to the engraving of music, and collections of patterns. On the return of Sennefelder to Munich, several stone printing houses were established under his direction in that city, where lithography has been brought to a very high degree of perfection. By slow degrees this invention travelled into France and Italy; but it was not prosecuted in these countries with success until 1807. Sennefelder had early communicated his invention to M. Andre d'Offenbach, who applied it with great success to the printing of music at Frankfort; and whose son, a merchant in London, first introduced it into Britain in 1801, under the name of *polyautography*, so called from its capacity of multiplying drawings from the hands of the artist. Mr. André entered a caveat in the patent office, but delayed taking out a patent, lest the specification which he would be obliged to make should lead to a discovery of the process. He obtained many fine drawings on stone, by some of the most eminent draughtsmen in London, which his successor, Mr. Volweiller, afterwards published in numbers, containing six impressions, at half a guinea each. Six of these numbers made their appearance; but the sale of the work was so limited, that Mr. Volweiller, disappointed in his expectations, returned to Germany in 1807. The art, since that time, has not made much progress in this country; and, while the war lasted, was confined to the quarter-master-general's office at the Horse Guards, where it was employed for the printing of plans of battles and maps of the seat of war. In Germany, however, the lithographic art is still carried on with great spirit, and several works of considerable merit have issued from the presses of Sennefelder. In Paris it is carried on with great success, in the Lithographic Establishments of count Lasteyrie and M. Engelmann, both of whom have produced some exquisite works; and Mr. Ackerman has some time since commenced the art in England, with the aid of a Bavarian artist.

Having given this short history of the invention, we shall now proceed to explain briefly the principles upon which it is founded, and give some details of the different processes of the art.

The lithographic art rests upon the three following principles: 1. The facility with which water is imbibed by calcareous stones: 2. The strong adhesion which exists between resinous or oily substances and calcareous stones: 3. The affinity which resinous or oily substances have for each other, and the quality which they possess of repelling water, or any body moistened with water. From these principles the following results may be deduced: 1. That the tracings made upon the polished surface of a calcareous stone with any resinous or oily substance adhere so closely to it, that they cannot be removed without employing mechanical means for their separation: 2. That while the other parts of the stone receive and imbibe the water which is poured upon it, the water is repelled by the resinous or oily parts: 3. That when any coloured substance of an oily or resinous nature is passed over the stone thus prepared, the colour will adhere to the resinous tracings, while it will be resisted by the watered parts of the stone. The process, in short, depends entirely upon the watered parts of the stone refusing the oily colouring matter, and the resinous tracings repelling the water; so that when a sheet of paper is applied to the stone, duly prepared, the oily tracings, which alone are coloured, give the impression.

Lithographic engravings may be divided into two principal kinds: those produced by a simple tracing made upon the stone with a pen, a crayon, or pencil; and those produced by the aid of the burin or graving tool, in the same manner as is done upon copper. To the former of these, however, we shall chiefly confine our remarks, as it alone can be employed with advantage. The other can never equal an engraving upon copper, or indeed answer so well any purpose to which the graver is applied.

All calcareous stones susceptible of a fine polish, and capable of being penetrated by an oily substance, and of imbibing water with facility, are applicable to this art. The more compact they are, however, the more valuable, as when they are too porous, the finer touches of the artist are lost. It is necessary also that they be of a uniform colour; for if the ground is at all varied, the designer is prevented from judging of the effect of his touches, and cannot regulate his efforts with precision. The quarries of Germany abound with stones of this description; and when Mr. André introduced the invention into Britain, he brought them from that country. They were, indeed, thought to be peculiar to Germany; but it has been discovered, that a similar stone is to be found in great abundance in the neighbourhood of Bath, and which is equally eligible for the purposes of lithography. It is the *white lias*, or layer, which forms the stratum lying under the *blue lias*, which last is there used for burning into lime, paving the streets, and other coarse purposes. It takes a very good polish, is compact, fine grained, and of a beautiful white colour, and may be procured of any superficial dimensions. Pretty good stones have been found in Scotland at Gosford, the seat of the earl of Wemyss and March, and we understand that others have been found, more recently, in the isle of Skye. When such stones, however, cannot be obtained without difficulty, or at great expense, it is more advantageous to fabricate factitious slabs, to which a proper density and hardness may be given. An intelligent potter can easily imitate the density of natural stones; and in consequence of their density, and the fineness of their grain, they are rendered susceptible of any requisite polish. Slabs used for this purpose have been made of stucco composed of lime and sand, and fastened with the caseous part of milk. Artificial stones have, however, not been made so as to equal the real ones; and the Royal Institute of France have thought it of sufficient importance to offer a large prize for the best.

In preparing the stone for receiving the drawing, the operation varies according as it is intended for the pen and ink, or for the crayon or pencil. In both cases, the slab must be of an equal thickness, from two to three inches, and of a size proportioned to that of the design to be executed. The surface must be made perfectly level; and, if intended for the pen, finely polished with pumice-stone and water. If the crayon, however, is to be used, it is necessary to granulate the surface, so as to afford some resistance to the chalk or crayon, and make the stone better retain the impression. This is done by means of fine sand and a muller, or flat piece of marble.

The chemical ink and chalk used in lithography are of a saponaceous quality, and should have the property of adhering with facility to the stone, and of resisting the action of water.

Various compositions have been employed for this purpose. The first chemical ink in use consisted of five parts of gum-lac, one part of tallow, one of mastick, and one of soda or potash, mixed together with a sufficient quantity of lamp-black as colouring matter. But great improvements have been made in this department of the art. In Germany, the *chemical ink* is prepared by combining one ounce of tallow-soap, two ounces and a half of pure white wax, a quarter of an ounce of tallow, and a quarter of an ounce of lamp-black. The soap, after being finely scraped, is put into an iron pot; when melted, the wax and tallow are added and well stirred; the composition, when quite hot, is inflamed; the lamp-black is then added to the mixture, by stirring it in during the boiling. When sufficiently boiled, it is poured out on a marble slab, and allowed to cool. The ink is made by dissolving this substance in distilled water. The *chemical chalk* of which the crayons are made is prepared by melting together one ounce of tallow-soap, five ounces of white wax, a quarter of an ounce of tallow, and one ounce of lamp-black; to these ingredients when boiling, add five or six drops of potash dissolved by the air; a strong ebullition is then produced, during which the composition must be well stirred and kept boiling until the froth has subsided, and the liquid mass becomes uniform. It is then poured out upon a marble slab, and, when cool, cut into slices for use. A more simple preparation, however, may be employed, which is easily made, and perfectly adequate to the purposes of the art. Take any quantity of *heel* or *shoe-ball*, used by shoemakers; add to this, one-fifth of its weight of tallow, one-fifth of its weight of lamp-black, and one-fifth of its weight of soda; melt the whole together, and allow the compound not only to boil, but to ignite for a minute or two. When completely dissolved, and of a uniform texture, it is poured out upon a marble slab, and forms the *chemical chalk*. Of this make a solution in distilled or rain water, with the addition of an equal quantity of shell-lac dissolved in water by means of soda, and the chemical ink is formed. In dissolving shell-lac in water, a boiling heat is necessary, and the soda is added in sufficient quantity until the solution is completed. The chemical chalk may be rendered harder, if necessary, by adding one-fifth of shell-lac to the above ingredients during their fusion.

When the chemical ink is used, a crow quill is perhaps the best that can be employed. The slit must be long, and the nib of a breadth proportioned to the fineness of the drawing: indeed, it is necessary to have several pens with points of different breadths, so that the designer may be enabled to vary his touches at pleasure. A Chinese hair pencil, or a steel pen, may be occasionally used; but the latter is very apt to cut the stone, unless in the hands of a very careful artist. In taking the impression from the stone, a screw press, a lever press, or a rolling press, may be employed. The balls are similar to those used by printers in general; and the ink with which the plate is daubed is made of lamp-black, (previously well burned in a close crucible,) ground with linseed oil, and prepared as for copperplate.

Being now furnished with the instruments and materials of the lithographic art, the artist proceeds to the executive part of the process, to trace his design upon the stone. But it is necessary to observe, that, before commencing his operations, care must be taken that the slab be made perfectly dry, and even in some degree warm, and that every particle of dust be removed from its surface, lest the tracings should be intercepted, and so not sufficiently adhere to the stone. The bare hand also should on no account be allowed to touch it after this preparation; for this would grease the plate, and would discover itself in printing, by receiving, instead of resisting, the chemical ink. We would observe, likewise, that the effect of gradation of tint is produced wholly by regulating the breadth of the line of the tracings, and not by their strength of tone, whether the pen or the crayon be used; and that the tracings appear stronger and more marked before the impression than afterwards, which is the reverse in common engraving. As the chemical ink is apt to become thick, the pens should be frequently cleaned, that it may flow from them more freely; and all repetition of strokes should be carefully avoided.

When the drawing or writing with the chemical chalk or ink is completed, and allowed to become perfectly dry, water (very slightly acidulated by means of vitriolic acid) is poured over the stone plate. This, by the laws of chemical affinity, takes up the alkali from the saponaceous ink or chalk, and leaves an insoluble substance behind. It also, in an almost imperceptible degree, lowers the surface of the stone, where free from the tracings of the design, and prepares it for imbibing the water with greater facility. A weak solution of gum-arabic is then applied, which has the effect of closing up the open pores of the stone, and keeping it in a proper state of moisture. The slab is again well washed with water, and the balls loaded with the daubing ink applied while it is wet. This ink, being also of an oily substance, is repelled by the watered parts of the stone, but received by the drawing, upon which no water can lie. The plate is then passed through the press in the usual way; and at each impression the process of watering and daubing with ink is repeated.

Instead, however, of tracing the drawing or writing upon the stone, the original may be first designed on paper with red chalk, which, for this purpose, is preferable to any other material, and then transferred to the stone by laying its face flat upon the slab, and rubbing the back with a burnisher. This will give a reversed impression upon the stone, so that the print from it will be the same as the drawing. A soft black lead pencil may also be employed; but the more faintly the drawing is performed in either case, so as to be seen, the better, as the tracings of the chemical ink or chalk might otherwise be intercepted.

Another method of transferring to the stone any drawing or writing done on paper, is frequently practised, and affords an easy and expeditious way of obtaining an indefinite number of copies of letters, plans, or other designs. The paper on which the design is to be made, is first varnished over with a solution of gum or size, and the tracings are then drawn with the chemical ink. The polished slab to which the drawing is to be transferred, is slightly granulated, made perfectly dry, and moderately heated. The paper is then laid flat upon the stone, with the drawn side downward, and passed through the press. When the frame of the press is raised, the paper is found adhering close to the stone; but, as the varnish with which it is covered is very soluble in water, it is slightly wetted, and then removed with ease. If the operation has been properly performed, the letters or tracings will remain fixed upon the slab, while scarcely a vestige of them will appear upon the paper. In effecting a complete transfer of the writing or drawing, care must be taken to have the paper well varnished, and the stone of a sufficient heat. Some artists prefer varnish made of gum tragacanth and starch: and soak the drawing in water previously to its being placed upon the slab. The same process is then followed in taking impressions, as when the drawing is made upon the stone.

Imitations of cameos may also be obtained by this invention, either with the graving-tool or with the pen. When the graving-tool is employed, the slab must be completely covered with the chemical ink; when dry, the design is traced with the graver, which cuts the surface of the stone, and erases the ink, so that the cut part of the stone is rendered pervious to water. The slab is then well washed, and the daubing ink applied, which is repelled by the water tracings, and gives a white impression on a coloured ground. When the pen is used, the design is traced with a strong solution of the purest gum arabic, coloured with China ink, or any other vegetable substance. When perfectly dry, the stone is oiled over, and then thoroughly washed. By this process, the gum tracings are erased, and the slab appears a perfect blank. But when the printing-balls are applied, the ink is received by the oiled parts of the stone, while it is refused by the tracings, and renders an impression similar to the former.

The lithographic art possesses many advantages peculiar to itself; and may be adapted to many valuable purposes. It is greatly superior to all other kinds of engraving in expedition and economy; and it is affirmed, that in the stone printing-houses at Vienna, thirty thousand impressions have been taken from one plate, while the last print was nearly as good as the first. Count Lasteyrie, we are informed, has taken off even 70,000 impressions. Even when the burin or graving-tool is used, the work is executed with equal dispatch. In the engraving of music, in particular, to which this art has been much applied on the Continent, double the number of pages can be executed in the same time as upon copper. The proofs are also easier taken; and a stone printing press will throw off 20 per cent. more copies in the same time than a copperplate press. The cheapness and durability of the material is another source of economy; and while the plates of copper are of little value after they have been used, the stone is so slightly cut with the graver, that the same slab may be repeatedly polished, and always be equally fitted for the purposes of engraving as at the beginning. Though this art may be applied to the imitation of any kind of engraving, yet it must be allowed, as was formerly observed, that no engraving upon stone with the burin can equal in fineness a copperplate engraving. The tracings made by the graver upon stone have a peculiar character, and render the print similar in kind, rather than a perfect imitation of copperplate. A skilful artist, however, of the lithographic school may approach very near, in fineness of touch and in freedom of execution, to the engraver on copper; as is evident from some of the landscapes published by Sennefelder, and from the productions of Count Lasteyrie, M. Engelmann, and Mr. Ackerman.

If cheapness and dispatch are apparent in this art, when the graver is employed, they are doubly so when the drawing is executed with the pen or crayon. This method furnishes numerous applications, and such as cannot be obtained by any other kind of engraving. Wherever precision is required, its superiority is evident. The naturalist, the architect, the painter, or the penman, have only to draw their figures with resinous ink upon varnished paper; and, by the process already explained, they may obtain as many proofs as they desire, possessing all the spirit and correctness of the originals. Whatever ease or softening is communicated to the drawing on the paper, the same is preserved in the impression from the stone. This is indeed the grand object to which the lithographic art ought to be chiefly applied, the *multiplying drawings from the hand of the artist* ; and " from this destination," says an anonymous writer on this subject, " it ought never to be diverted. What a rich inheritance might have descended to us, if the old masters had possessed this art! The high price now so justly attached to their drawings and first sketches is sufficient evidence of the estimation in which they are held. The finest etchings or engraving from any such drawings or sketches, are, at the best, but translations from one language into another, and never can give the spirit of the original. It is impossible not to feel how much benefit would have been derived to the fine arts, from the multiplication of the drawings of the masters, and their universal diffusion. Whatever the poet has effected by means of the press, the painter would have achieved with the same facility. Those rapid effusions of the imagination, those spirited sketches and brilliant first thoughts, never perhaps realized even in the finished painting, by this invention might have been given to the world with unlimited liberality; the facility of the work, and the cheapness of the process, dissipating every difficulty that prevented the master so satisfactorily multiplying his drawings. And let it be remembered, that the production of the lithographic press will be *fac-similes* of what is excellent, *multiplied originals*, instead of spiritless copies."

We shall conclude this article with the following directions, by the same writer, for drawing with the pen upon stone, as applied to landscape.

" Begin with the extreme distance, and use a pen that has a very fine nib, and a long slit to carry the ink; draw the contours of objects only as they appear in mass, as broad as possible, to give the effect of distance. With a somewhat broader nibbed pen, put in the middle distance; and, in addition to the simple contours of objects, enter a little into the detail of their larger masses. On the foreground use a still broader pen, and give every object its local character and form in correct detail, which is the only mode of giving the effect of nearness, while it also tends to throw the other parts of the drawing back. As there is no such thing as outline in nature, the lines by which we describe the forms of objects should be, as much as possible, confined to their shade side; and as shadows always lie underneath, it is particularly to be remembered to begin by tracing the contours of masses at this part. The shadows in general should be expressed by parallel straight lines which have no local character, but more particularly in the distance. On the foreground, the transparency of shadows will be better preserved by tracing out the forms of the objects in a broader stroke of the pen. It adds to the harmony of the drawing, that the shade lines should all go one way, and parallel to the rays of light. The sky may be done last; and little more is necessary than a few clouds, to prevent the disagreeable effect of so large a portion of the drawing being as it were a blank. Let it be remembered, however, that there is a rule for drawing these clouds; their shade tint must be produced by parallel lines gently waving and deviating from the line of the horizon. The principle upon which the outlines of a pen and ink or pencil drawing in black and white are filled up, is called the mezzotinto, or middle tint, or the tint between light and shade: it is best produced by straight parallel lines, of different degrees of strength. This tint, however, is not used on the fore ground, where the light should be in undiminished strength. It is particularly recommended, that the whole of the drawing should be made with as few lines as possible in the first instance. It is a perfection in drawing to give the local character of any object by as few touches as possible; and there is an advantage in this mode, in the opportunity it gives of promoting the effect of aerial perspective, by more amply marking out the objects near to you, and where the strongest lights are suppossed to fall in finishing. The first state of a drawing is like the dead colouring of painting. The subsequent touches on the drawing bring it up to life, like the second and third paintings of a picture, which improve the lights, strengthen the shadows, and make out local character. Indeed, it is a good plan to imagine that you are at first drawing with so little light that the contours of the masses can only be defined; then suppose a little more light, which exhibits them more in detail; and lastly, that sufficient quantity of light which makes every thing properly obvious."

To enable amateurs to practise this beautiful art, and to go through the whole of the process themselves, lithographic printing-presses are manufactured by Mr. John Ruthven, Edinburgh, and sold at a very moderate rate.

For farther particulars respecting the subject of this article, we refer our readers to the pamphlet already alluded to, entitled *Lithography*, or *the Art of taking impressions from Drawing or Writing made on Stone.* Also to M. Marcel de Serres, *Essai sur les Arts et les Manufactures de l'Empire d'Autriche*, tom. ii. p. 51, &c. (*p*)

LITHOTOMY. See SURGERY.

LITHUANIA, a very extensive country in Europe, and formerly a separate duchy, now forms part of Poland. See POLAND and PRUSSIA.

LIVER. See ANATOMY, and also MEDICINE and PHYSIOLOGY.

LIVERPOOL, the second sea-port town in the British empire, stands on the eastern shore of the estuary of the Mersey, in 53° 22′ North Lat. and 2° 30′ West Long. reckoning from London, from which metropolis it is 204 miles distant. By referring to ancient records, we find that the name had, during the unsettled state of orthography, undergone various changes; having been, at different periods, written *Litherpul, Ly'rpul, Lyvrepul, Lyrpole, Lyverpole, Leerpool, and Leverpool*, before custom had fixed it in its present form. Its etymology is uncertain; but the most probable conjecture is that, we think, which derives it from *lither* (*i. e.* lower) and *pool*, with reference to a small creek, in an old act of Parliament called "the pool," which formerly occupied the site of the Old Dock and Paradise Street.

As Liverpool was late in emerging from obscurity, it is not once noticed in the ancient history of England. It seems probable, indeed, that the town had no existence at all till after the time of the Norman Conquest; for its name does not occur in Doomsday-book, although several of the neighbouring villages are distinctly registered in that curious record. It certainly did not attract any considerable notice till after the subjugation of Ireland in the 12th century, when its local position was found to render it a convenient port for maintaining military as well as mercantile communication with that island. For these reasons, it was then taken under the royal patronage; and A. D. 1173, Henry II. granted its first charter in the following terms: "Sciatis quod totum æstuarium de Mersha sit in perpetuum portum maris, cum omnibus libertatibus ad portum maris pertinentibus; et quod homines de Lyrpul quondam vocant Litherpul, juxta Stokestede, ex utraque parte et aque veniant redeant navibus et mercandis, libere et sine obstructione."

A second charter was granted by John in 1207; and twenty years afterwards, both were confirmed by Henry III. who gave the town a merchant-guild and other privileges. From this time forward, the port rose, though very gradually, into consideration. Its imports were chiefly from Ireland, and were at first confined, almost exclusively, to linen-yarn, fish, and hides; its principal exports being woollen-cloths, iron, charcoal, armour, horses, and hunting dogs.

It is curious and interesting to mark the progressive advancement of a town which now ranks so high among the ports of the empire. Till the beginning of the 16th century, when it was visited by Leland, it had gained but little; but still it had gained something. "Irisch marchauntes," he says, "cum much hither as to a good haven;" and he states, as one great cause of their preference, that "at Lyrpole is smaule custume payid." He adds, "Good marchandis at Lyrpole, and moch Yrisch yarn that Manchester men do by (buy) ther." Still, although he describes Lyrpole as a thriving and "pavid towne," the king having a castelet, and the Earl of Derby a stone house there, he informs us, that it was not considerable enough to possess a parish church, having only a single chapel, dependent on Walton, from which it was four miles distant. In 1565, the population fell somewhat short of 1000, and the shipping consisted only of ten barks and two boats; the port having, from some unknown cause, experienced a temporary reverse of fortune. This the inhabitants did not scruple to acknowledge, a few years afterwards, when, in a petition to Queen Elizabeth, they styled the place "her Majesty's poor decayed town of Liverpool." During the civil wars in the reign of Charles I. Liverpool, which at that period possessed a large castle, and was strongly fortified, being in the hands of the Parliament, was judged of sufficient importance to be invested by the king's nephew, Prince Rupert, in person, who, after a hard struggle, succeeded in taking it, A. D. 1644. It was soon, however, regained by the troops of the insurgents. During this contest, great part of the town was unhappily destroyed by fire. In 1699, the population having by that time increased to about 5000, Liverpool was, by act of Parliament, erected into an independent parish, with two rectors, who, as well as their successors in office, should be nominated by the mayor, aldermen, and council for the time being, and should enjoy equal right to the fruits of the benefice. The old parochial chapel was, from that date, occupied by one of the rectors, under the name of St. Nicholas' Church; and the other rector was soon furnished with a new church, called St. Peter's. Still, however, the place was not a port of note in foreign parts. In Baudrand's *Dictionnaire Geographique*, a work of high character, published in 1705, we observe Manchester and Preston recorded as flourishing towns in Lancashire; but the name of Liverpool is not to be found. The commerce of Liverpool continuing gradually to extend, an act of Parliament was obtained in 1710, empowering the town to construct a wet dock. This, as being the first of which the port could boast, has since, in reference to those of later construction, been named the Old Dock. There were, at this time, 84 ships belonging to Liverpool, averaging somewhat less than 70 tons each, and navigated by 11 men at a medium. But the port was frequented by above three times that number of stranger vessels. About this period, the enterprising spirit of the merchants was shewn in their speculative adventures to the West Indies and America; and having obtained the most encouraging success, their shipping increased so rapidly, that, by 1716, they sent out 113 vessels, whose burden amounted to 8386 tons, and which were navigated by 1376 men. For the exclusive preference they obtained from their transatlantic correspondents, they were no doubt indebted to the superior skill of the Manchester manufacturers, from whose looms they received the checks, stripes, osnaburgs, and handkerchiefs which they exported. The prosperity of the town evinced itself in a way truly gratifying to every philanthropic mind, by beneficent endowments for the relief and instruction of the poor, and further provision for the religious improvement of the still rapidly increasing population. A charity school (the blue coat hospital) was founded in 1709, and in 1715 an act was obtained for building a third church, which was some years afterwards reared on the site of the castle, that fortress having been demolished in 1659. This new place of worship was named St. George's, and is the corporation chapel.

The town continuing to enlarge as its commerce increased, the number of inhabitants, by the year 1720, amounted to 10,446. This year produced an act of Parliament for opening an inland navigation betwixt Liverpool and Manchester; an act in which both of these towns were deeply interested. Authority was at the same time obtained for securing communication by water with the rich salt-mines and brine-pits of Cheshire. This arrangement contributed prodigiously to the subsequent prosperity of the sea-port. The fortunes of the manufacturers of Manchester being now closely united to those of the Liverpool merchants, an opportunity was soon afforded to the former of profiting by the exertions of the latter, for circulating their commodities to an unprecedented extent; and as these fabrics continued to sustain the high character they had acquired, the foundation of future opulence was thus effectually secured to both the sister towns. We allude to a contraband trade with Spanish America. To escape the exorbitant duties imposed by Old Spain on woven goods regularly imported into her colonies in South America, some small vessels were secretly sent out from the creeks and obscure ports in the latter country to Jamaica, where they eagerly bought up every article which they could obtain of Manchester manufacture, paying an extravagant price on the spot, and in actual specie. In this branch of illicit commerce, British manufactured goods, to the astonishing amount of a million and a half, are said to have been annually vended; but, about the year 1740, this traffic was checked by the vigilance of the Spanish government, and it was soon after totally abolished by an act of our own legislature.

But, before this period, the cupidity of some of the Liverpool merchants was directed to a trade which, although not interdicted by the laws of nations, bade direct defiance to those of humanity. Bristol had long carried on a successful traffic in live human flesh; and Liverpool, envying her unhallowed gains, became her competitor in that nefarious speculation. By selling their negro brethren four or five pounds a head lower than their rivals, which their superior economy enabled them to do with equal profit, the Liverpool slave-dealers insured the command of the market; and accordingly, by the year 1764, they had no fewer than 74 slave ships in their constant employ, being more than one-fourth of the shipping belonging to their port, and more than one-half of the total number of African vessels belonging to Great Britain! At this period, the number of inhabitants in the town was about 26,000.

From this time forward, Liverpool has not only continued to assert her high rank as a commercial town, but the opulence and enterprising spirit of her merchants has secured her progressive and rapid aggrandizement. Her population amounted, in 1773, to 34,407; in 1790, to 56,000; in 1797, to 60,000; in 1801, to 77,653; and in 1811, to 94,376, exclusive of 7000 sailors. In 1793, she possessed 92,098 tons of shipping; in 1800, no fewer than 4746 vessels entered her port, the amount of whose burthen was 450,060 tons; and in 1810, the number of vessels had been augmented to 6729, making 734,391 tons.

The slave trade, although a powerful instrument in advancing the fortunes of Liverpool, and in securing her pre-eminence as a trading port, was happily destined not to continue her principal source of opulence. The zealous and indefatigable exertions of a Wilberforce and a Clarkson succeeded in convincing many, even of the merchants of Liverpool, that human beings could not be bought and sold in a market with innocence; and at the memorable struggle in the British legislature, when justice and humanity gained so glorious a triumph over self-interest, Mr. Roscoe, one of their own representatives, and their fellow citizen, had the virtue to vote for the eternal extinction of that lucrative, but cruel branch of commerce.

The embarrassment occasioned by the abolition of the slave trade was of short duration. The bold spirit of adventure which the merchants had by this time imbibed, instantly prompted them to explore new channels for the employment of their ships; and their intelligence, capital, and credit, insured success. In particular, their commercial intercourse with America and the West Indies became more intimate and extensive. Nor could they discover any good reason why they should be debarred access to the treasures of the East. A long while previous to this, indeed, there had been an abortive application from the merchants of Liverpool to the East India Company, for a certain number of their vessels to be annually fitted out and laden from that port; and in the year 1792, in the prospect of losing the slave trade, some strong resolutions were passed at a public meeting in the Exchange, expressive of the sense which the merchants entertained of the impolicy and injustice of monopolies in general, and of the East Indian monopoly in particular; and as the Company's charter was about to expire, a committee was appointed to petition the legislature "against the renewal of an exclusive charter, by which the commercial, manufacturing, and, by consequence, landed interests of the kingdom were so manifested injured." These resolutions being extensively circulated in the manufacturing and mercantile quarters of the united kingdom, excited much interest; but our political relations with regard to France were at that period of a very delicate nature, and it was feared by many that any opposition to administration might weaken the hands of government at a period when they required rather an accession of strength. Besides, the commercial body very soon afterwards received a most unexampled shock, by the numerous bankruptcies which took place throughout both the British islands; and from this complication of causes the prospect was abandoned for the time. But, in 1813, when the charter of the London monopolists was again near an end, a favourable opportunity occurred of renewing the application to parliament for laying the India trade open to competition. The proposal was stoutly resisted by the Company, whose advocates did not scruple to declare, that the trade to British India would admit of no extension from the utmost freedom of private enterprize; that competition would, in India, enhance so much the price of every article, that the Company would be unable to buy, and in Europe reduce the value so much, that the Company, as well as the private adventurers themselves, would be utterly ruined by selling; that there was a mysterious something in the constitution of the Hindoos, which would prevent them from raising a supply to meet an increased demand for their commodities; that all Asiatics are timorous, and unwilling to hold intercourse with strangers; and that private merchants would be unable to conduct their trade in the east without the assistance of a military force to protect their factories. But when the Company complained that private competition would enhance the price of Indian commodities, they intimated, in other words, that it would encourage industry among the natives; and when, with perfect consistency, they complained that it would, in the home market, lower the price of Indian produce, they only predicted that it would greatly extend the consumption. Now, these are the very means by which the progress of national prosperity is to be accelerated. The best answer to the other assertions is a reference to facts. The trade to India, which the Company declared to have been, for the last 15 years, a losing concern to them, has been thrown open to Liverpool and a few other trading towns, and has already proved most encouraging. None of the threatened disasters have occurred, or are likely to occur. One vessel of 512 tons was fitted out for this new traffic in consequence of the act, and returned, in 1815, under such favourable circumstances, that, in 1816, Liverpool possessed eight Indiamen, (burden amounting to 3831 tons;) in 1817, they were increased to 17, the burden amounting to 7538 tons; and at this date, (September 1818,) no fewer than 80 different vessels have been employed in the trade since its commencement. In short, the prospect of advantage to the town from this measure is most flattering. The articles exported to India, have chiefly been broad cloths and woollens, Birmingham hard-ware, and Sheffield cutlery, Manchester and Glasgow piece goods, Nottingham hosiery, Staffordshire earthern ware, Irish linens, iron, copper, lead, salt, glass, hats, malt liquors, and dollars. The imports are cotton, rice, indigo, sugar, saltpetre, ginger, pimento, and other spices, turmeric, safflower, and other dyes. It is to be regretted that the China trade, by far the most lucrative branch of our commerce in the east, is still in the hands of the privileged monopolists.

It has been estimated that one-twelfth of the shipping of Great Britain is furnished by Liverpool; that it has one-fourth of her foreign trade, and one-sixth of her general commerce, and that its exports and imports amount to not less than one-half of those of London. The following abstract exhibits the average number of vessels reported at the Liverpool custom-house, from the beginning of 1802 to the end of 1817, exclusive of coasters, which, if added, would nearly double the totals.

Annual average number of Vessels.

Annual average from	From Europe.	Africa, America, W. Indies, &c.	Ireland and Isle of Man.	Totals.
1802-8	401	604	1219	2224
1809-13	351	755	1610	2716
1815-17	742	489	1701	2932

From Europe, 578; British vessels from foreign parts, 590; foreign vessels from foreign parts, 279; from Ireland and the Isle of Man 1773; total 3220.

In 1724, the amount of dock duties was only 810*l.* 11*s.* 6*d.*; in 1815, it was 76,915*l* 8*s.* 8*d.*; when the official value of the imports amounted to 8,000,000*l.* Sterling, and of the exports to 12,000,000*l.* The value of the shipping was at the same time estimated at 7,000,000*l.* In the year ending 5th July, 1818, the number of ships amounted to 6779, the tonnage to 754,690, and the duties to 98,538*l.* 8*s.* 3*d.* exceeding by several thousand pounds the receipts of any former year.

In a port like Liverpool, the docks naturally attract the attention of the intelligent stranger, and they are calculated amply to gratify his curiosity. The wet docks are chiefly occupied by ships in the foreign trade, which have large cargoes to receive and to discharge. In them the ships are afloat at all times of the tide, the water being retained by gates. The dry docks are frequented by coasting vessels. The graving docks, which admit or exclude the water at pleasure, are appropriated to ships requiring repair. As the docks are liable to accumulations of mud, they have subterraneous communications with each other by means of large tunnels, so that, when it is necessary, the water of one or more is made to wash out another. This operation is performed annually. The dock to be cleaned is left dry at low water, and the sluices being then opened into it in different directions, a number of men with spades throw the mud into the currents.

On the sides of the docks are warehouses of uncommon height and strength, to the different floors of which goods are craned up with surprising facility. Under the same roof the proprietors often have their counting-houses; and as their vessels are thus loaded and unloaded at their very doors, we question if there be any mercantile town in the British dominions which affords equal conveniences to the man of business. Some of these docks have of late been greatly enlarged; and the first stone of a new one, of very spacious dimensions, was laid in 1816. This is to be named the Prince Regent's, and will soon be completed, when the total space occupied by the different docks will exceed 60 acres.

The internal economy of each dock is regulated by an officer appointed for the purpose, and the general superintendance of the port is committed to a harbour master.

The dock office, for receiving the duties, the dock police-office, and the custom-house, are all situated near the old dock. There is nothing striking in their architecture. But the exchange buildings deserve more particular notice. This is an elegant and magnificent structure, on a scale suited to the opulence of the men for whose use it was erected. It was begun in 1803, and finished in 1807, at an expence little short of 100,000*l.* It forms three sides of a quadrangle, in the centre of which is a superb group of bronze statuary, elevated on a pedestal of Westmoreland marble, allegorically representing the death of Nelson in the moment of victory. This monument, which was finished in 1813, was designed by Wyatt, and cast by Westmacott, the expence being upwards of 9000*l.* raised for it by subscription in a very few days. In the area which surrounds this, the merchants transact their business, the space being twice the extent of London exchange. The fourth side of the quadrangle is occupied by the town-hall, another building worthy of the place. Its principal front forms the termination of Castle Street, by far the most beautiful of the streets appropriated to business. The interior, which, in 1796, had been destroyed by fire, is now repaired in the most splendid style, at an expence of more than 60,000*l.* The corn exchange is a good specimen of Grecian architecture. It is modern, and cost about 10,000*l.* The jail is a very extensive, well-aired building, constructed on the plan recommended by the humane Howard. The place formerly used for the purpose was an ancient fortification called the Tower, supposed to have been built in the 14th century. We are happy to observe, that the attention of an enlightened magistracy has lately been turned to the important object of providing employment and instruction for the prisoners. The fort has a spacious area, and barracks for the soldiery. Its guns command the river in every direction. It was constructed, we believe, for the protection of the shipping, at the time when Paul Jones threatened a descent on the coast. The theatre, music-hall, assembly rooms, public baths, and other places of recreation, are all suited to the opulence of this great commercial town.

The rapid increase of population required a correspondent provision for the spiritual instruction of the inhabitants of Liverpool. Accordingly, the churches and dissenting chapels are very numerous, and receive yearly additions. The churches, besides the three formerly mentioned, are St. Thomas', St. Paul's, St. Anne's, St. John's, St. James', Trinity, St. Catherine's, St. Stephen's, St. Matthew's, Christ's, St. Mark's, All Saints', St Andrew's, and St. Clement's, but still more are projected. The dissenters are numerous. There are two Scotch congregations, one of them in connection with their own national establishment, the other being Burgher Seceders. The Independents have 3 chapels; the Baptists 4; the Methodists, of different denominations, 7; the Roman Catholics 4; the English Presbyterians 2; the Glassites 1; the Swedenborgians 1. The Quakers also have a meeting-house, and the Jews a synagogue.

Liverpool is eminently distinguished above other towns by the comparative number and the admirable economy of her benevolent institutions. They are, generally speaking, so wisely devised, and so faithfully administered, that we much regret the narrowness of the limits to which our notice of them is restricted. We must, however, at least name the most remarkable:—as, a District Committee of the Society for Promoting Christian Knowledge; an Auxiliary Bible Society; Charity Schools, with the following distinguishing titles: Moorfields, Roman Catholic, Hunter Street, St. James', St. Matthew's, Manesty-lane, Circus Street, Caledonian, Brunswick, and Harrington, besides a Marine Evening School for poor sailor boys; the Quakers' School for poor female children; and many Sunday schools attached to different chapels, both for children and adults. The children educated at the charity schools connected with the establishment alone, who assembled to the annual sermon in 1818, amounted to 1544 boys, and 771 girls. The Welsh Charitable Society for instructing, clothing, and apprenticing poor children of Welsh parents; the Benevolent Society of St. Patrick, on a similar principle, for the children of Irish parents; and a Society for the Relief of Poor Free-Masons, are all excellent in their kind. The infirmary, which is conducted on the most liberal principles, stands on an elevated, open, and healthy station, and possesses an extensive garden. About 1500 patients are admitted annually, and medical aid is also extended to many in their own homes. Connected with the building of the infirmary, but not with its economy, is an Hospital for the Maintenance of Decayed Liverpool Seamen, and their widows and children, supported by the monthly allowance of sixpence, which every sailor belonging to the port is bound to pay out of his wages. The dispensary relieves about 15,000 patients yearly; but on occasions of extraordinary sickness, as in 1817-18, the number very far exceeds that. The House of Recovery for fever patients, stands in a free, well-aired, insulated site, and greatly tends to prevent the spreading of infection. The Institution for Restoring the Drowned, which does honour to the corporation, (its patrons and supporters,) has been the means, under Providence, of saving many lives. The ladies have an excellent Charity for the Relief of Poor Married Women in childbed, by which, in 1817, no fewer than 1623 persons had their distress greatly alleviated at an interesting juncture, and at an expence comparatively trifling. The Stranger's Friend Society extends help, with much liberality, to those who are far from home. The female Penitentiary promises to be very beneficial in reclaiming corrupted and miserable females to virtue, religion, and comfort. The House of Industry, a plain but handsome structure, affords its numerous inmates much more comfort than paupers in such institutions usually enjoy. The Blue-Coat Hospital clothes, lodges, and boards 160 boys, and 65 girls. They are taught reading, writing, and arithmetic, on Dr. Bell's plan; and the girls learn also to sew, to spin, to knit, and every thing that is useful in housewifery, the annual expenditure being somewhere about three thousand pounds. The Female School of Industry is a judicious and well-regulated institution for promoting the moral and religious education of poor girls, so as to make them industrious, useful, and respectable servants. There are about 80 in the house. The Society for Bettering the Condition of the Poor acts on the principle, that the best relief the poor can receive is that which is the fruit of their own exertions; and that their welfare can best be promoted by encouraging industry and prudence. It includes two Friendly or Benefit Societies, on a basis of correct calculations under *L*5. and a Bank for Savings, a provident institution for the earnings of honest industry above that sum. The commercial Clerks' Society supports its sick and destitute members, and attends to their poor widows and orphans when they die. A Society for the Relief of Debtors confined in the borough jail, furnishes protection to many oppressed seamen and foreigners against the wiles of rapacity. The School of Industry for the Indigent Blind furnishes employment and comfort to a class of human beings naturally most helpless and gloomy. The pupils, who are admitted from all quarters of the kingdom, are taught music, spinning, and the art of making hampers, baskets, sash-line, floor-cloth, sacking, sacks, list shoes, hearth rugs, foot bearers, points, gaskets, &c. &c.

Liverpool possesses few manufactories of note. There is an extensive pottery in the neighbourhood, where beautiful specimens of porcelain are produced, but those of chief importance in the town are such as are required for the furnishing and repair of the shipping, as the manufactory of iron cables, and the roperies. Of the last, the two principal are that of Messrs. M'Iver and Company, and that of Messrs. G. Duncan and Son. Steam is the moving power of both, and the machinery of both is highly ingenious; but they are constructed on different principles, and each is secured to its proprietors by a patent. That of Messrs. M'Iver and Company, the invention of a Scotchman of the name of Campbell, is, from its neat and compact arrangement, the most imposing to the eye; in the construction of the other, Mr. Duncan, senior, also our countryman, has directed his talents more immediately, by several beautiful contrivances, to ensure the strength of the article manufactured; and his genius is rewarded by complete success, every fibre of his cables and other cordage being available, which is far from being the case with regard to ropes manufactured on the common plan.

The markets of Liverpool afford every thing that the convenience or luxury of the inhabitants can demand. The fish market is well contrived and abundantly supplied, and no part of England can show a better furnished green-market. Coals are obtained from Wigan in great plenty, by the Leeds canal, and excellent water is distributed over the town by pipes, into which it is introduced by means of steam engines.

With regard to the government and police of the town, the body-corporate consists of 41 persons, composing the common council, from among whom a mayor, recorder, and two bailiffs, are annually chosen (28th October) by the free burgesses. Those who have borne the office of mayor are styled aldermen, and the three junior aldermen are coroners. The income of the corporation is not less than 60,000*l.* a year. A separate establishment has lately been appointed by act of Parliament, for maintaining the police of the docks, and one of its magistrates attends daily at the dock police office.

Liverpool sends two members to parliament, who are chosen, like the magistrates, by the votes of all the free burgesses not receiving alms. The number of men polled, in 1818, at the general election, was 2905, being more, by 200, than on any former occasion. The freedom of the town is acquired by birth, by serving an apprenticeship to a freeman, by purchase, or by obtaining a grant from the corporation. Freemen of Liverpool are also free of Bristol, of Waterford, and of Wexford.

Dr. Dobson thinks the situation of Liverpool renders it, in proportion to the number of its inhabitants, one of the healthiest places in the kingdom. Dr Currie, however, complains much of the multitude of low cellars and ill-ventilated back houses, which are continually generating typhus. The same philosophic physician states the succession of months in respect to their unhealthiness in that town, where he gained so much deserved fame as a practitioner, in the following order: March, April, January, October, May, December, November, February, June, September, July, August; March being the most sickly, and August the least so.

The residence of an enlightened and well educated clergy, and of such characters as a Currie and a Roscoe, even in a commercial place like Liverpool, could not fail to refine the taste of their fellow-townsmen, and to inspire them with a desire for intellectual improvement. There are several public buildings of great elegance erected for the express purpose of providing supplies of nourishment for the mind. Besides the periodical publications, these have extensive and well-selected libraries. That of the Athenæum contains upwards of 8000 volumes, and that of the Lycæum, 10,000. The library of the Union Rooms is not so comprehensive. There are besides many private book-clubs, of various descriptions. An establishment for the promotion of literature, science, and the arts, under the name of the Liverpool Royal Institution, was opened in November 1817, by Mr. Roscoe, who, on that occasion, pronounced an elegant introductory discourse to a numerous and admiring audience. The expence of this literary establishment will not fall short of 30,000*l.* It is "its avowed object," says Mr. Roscoe, "not only to establish a system of academical education, but to draw from every part of the united kingdom the best instructors that can be obtained, on those subjects which are of the first importance and the highest interest to mankind. By these means an establishment will be formed, original in its plan, and efficient in its operation; affording to the inhabitants an opportunity of domestic instruction for their children, equal, it is hoped, to any that can elsewhere be found." At a short distance from the town is a large and valuable Botanic Garden, like the former institution, supported by subscription, and containing a spacious and beautiful conservatory. All these institutions evince an elegant taste in the recreations of the inhabitants, which raises them above the rank of mere plodding votaries of Plutus. "They have no longer left the beneficial influence which commerce and literature have on each other, to be inferred from historical deductions or far-sought arguments, but have actually brought them together, have given them a residence under the same roof, and inseparably united the bold, vigorous, and active character of the one, with the elegant accomplishments and lighter graces of the other." The society of Liverpool being, to a remarkable extent, composed of individuals who are natives of distant parts of the kingdom or who have spent much of their life abroad, they are peculiarly free from local prejudices, and are distinguished for urbanity and for hospitality to strangers. The sudden vicissitudes to which their bold speculations and their mercantile connections expose the greater part of them tend, no doubt, to repress overweening arrogance and presumption. The public institutions evince their benevolence, their intelligence, and we hope we may add, their zeal for religion; but we do fear that luxury and dissipation, the natural attendants of opulence, have made too many proselytes among them.

See Aikin's *Description of the country round Manchester;* Campbell's *Political Survey of the British Empire;* Corry's *History of Liverpool*; Enfield's *History of Liverpool; General Descriptive History of the Town of Liverpool; The Stranger in Liverpool;* and Currie's *Medical Reports.* (Θ. T. Δ.)

LIVONIA. See PRUSSIA.

LIVY, (LIVIUS, TITUS,) the celebrated Roman historian, was a native of Padua. Of the circumstances of his life very few particulars have been preserved. During the reign of Augustus he repaired to Rome, where he obtained the notice and favour of the emperor, and cultivated the acquaintance of several persons of the most distinguished rank. Suetonius mentions, that Claudius Cæsar, afterwards emperor, when a young man, attempted to write history by the exhortation of Livy; whence it has been supposed that he had been appointed by Augustus to superintend the education of that prince. He had previously distinguished himself as an author, by some philosophical dialogues; but his reputation was principally founded on his great historical work, which he appears to have commenced soon after he was settled at Rome. After the death of Augustus he returned to the place of his birth, where he was received with the honour and respect so justly due to his talents; and there he died, upwards of 70 years of age, in the fourth year of the reign of the Emperor Tiberius, A. D. 17. A monument was erected to his memory in the temple of Juno, where the monastery of St. Justina was afterwards founded. Of his family little is known; but we learn from Quintilian that he had a son, to whom he addressed a letter, containing some excellent precepts on the study of rhetoric.

During his lifetime the character of Livy obtained universal respect and admiration. Notwithstanding the marked difference in their political sentiments, which he took no pains to conceal, he lived upon terms of uninterrupted friendship with Augustus and his courtiers. His fame, indeed, was so widely extended, that, as we are informed by Pliny the younger, an inhabitant of Cadiz travelled to Rome on purpose to see him; and having gratified his curiosity, he immediately returned home. Panormita, a native of Palermo in Sicily, and one of the ablest men of the fifteenth century, is said to have sold an estate, to enable him to purchase the works of Livy.

The great historical work of Livy, which was extolled in terms of the highest praise by all the posterior Roman authors, has been transmitted to us in a very imperfect and mutilated state. It consisted originally of 142 books, and contained the history of Rome from the foundation of the city to the year 744. Of these only thirty-five now remain, viz. the ten first, and from the beginning of the twenty-first to the end of the forty-fifth. In the oldest editions there are only twenty-nine books, and these not entire. The rest were discovered at different times, after the invention of printing; but some of them are still imperfect. An epitome of the whole, with the exception of two, (the 136th and 137th,) have been preserved; but it gives no more than the heads of the matter. The lost books have been supplied, in modern times, by Freinshemius. There is no ancient author the loss of whose works has been the subject of more regret among the learned than that of the writings of Livy.

The merit of Livy, as a historian, has been universally acknowledged. His narrative is copious, eloquent, and agreeable, and his descriptions lively and picturesque; though he possesses neither the sententious conciseness of Sallust, nor the philosophical spirit of Tacitus. His style was censured by Asinius Pollio, as not entirely free from a certain provincial impropriety, which, from his birth-place, he called *patavinity*. He has also been charged with credulity, in recording the vulgar prodigies of every year; and with an undue partiality to his countrymen.

The most esteemed editions of Livy's remains are, that of Gronovius, *cum notis variorum*, Lug. Bat. 1679, 3 vols. 8vo.; of Le Clerc, Amst. 1709, 10 vols. 12mo.; of Crevier, Paris, 1735, 6 vols. 4to.; and of Drakenborch, Amst. 1738, 7 vols. 4to. See *Vossius*, *Fabricius*, *Ziraboschi*, *Harwood*, &c.

LIZARD. See HERPETOLOGY.

LOADSTONE. See MAGNETISM and MINERALOGY.

LOANGO, a kingdom on the western coast of Africa. It was formerly a part of the great kingdom of Congo, but, like Angola, was dismembered from it, and established into a separate and independent state. It was formerly called the country of the *Oramas*, who were the ancient inhabitants; but it now has its name from the capital, which was named Loango by the French. It extends along the coast upwards of 100 leagues, viz. from 2° to 7° South Lat. and about 70 leagues inland to the Buchumelian mountains, so called from the prodigious numbers of elephants which inhabit them, and the vast quantity of ivory they afford. Its capital, of the same name, also called *Banza-Loangeri*, and by the natives *Boori*, is a considerable town, in an extensive plain, about two leagues from the sea-coast. The houses are meanly constructed, detached from one another, and shaded with palm trees. The royal palace consists of many apartments, surrounded with a palisade of stately palms. The bay is of difficult entrance, being but few fathoms deep. It is easily distinguished by lofty reddish mountains, which appear on the coast. Along the shore there is a rapid current, during most part of the year.

On the coast stands the *Capo Negro*, or Black Cape. so called by the Portuguese on account of its dark appearance, being shaded with trees. Here the sea forms a kind of semicircle or haven, called the Road of *Majumba*, the breadth of which to the opposite or southern coast measures about half a league. In stormy weather the sea throws up such vast quantities of sand into the haven, as to shut up the mouth of the river Combi.

This country, having but little southern latitude, is almost as hot as any in the torrid zone; nevertheless it is said to be as healthy as the milder and more southerly climates of Congo and Angola, and its soil equally fertile, and capable of improvement. The dry season begins with April, and ends with October; but the greatest heat is in the rainy season, or during the other six months. The climate is very pernicious to strangers. and, therefore, the use of flannel and bark is recommended; but the natives are so healthy, that one of their kings is said to have lived to the age of 128 years. Here may be found that uncommon race called *Albinos*, of whom see a description under the article ALBINO.

The natives, like all the other inhabitants of the African coasts, are so naturally indolent, and so remarkably averse to agricultural labour, that they will not cultivate more land, nor even sow or plant more than what is barely sufficient for their subsistence. Hence it unavoidably happens, that a bad season is followed by a famine, which carries off vast numbers of the inhabitants. In general they are satisfied with bread and fish, and such fruits and vegetables as the soil spontaneously produces. The productions are similar to those of Congo, and having been particularly described in that article, need not be repeated. They consist, in general, of several kinds of grain; of tobacco, cotton, pepper, pimento, sugar-cane, some fruits, abundance of roots, and luxuriant pastures. The inhabitants are too indolent to cultivate the cocoa, orange, and lemon; but the cotton and pimento trees grow without any culture. The palm, banana, and other trees, afford them good fruits and wines. The palm wine, the favourite African beverage, is procured by piercing the tree when the fruit begins to swell from the trunk. Peas and beans, large and small millet, they have in great abundance; for of these the ground produces no less than three crops in the year.

From the Ensanda, Alicondi, and Metamba, they derive the requisite materials for building their houses, boats, and sailing vessels. The Metamba may be found in every part of the country. It yields a very pleasant wine, inferior only in strength to that of the palm tree, and also supplies the timber which serves for building and making the furniture of their houses; while the leaves of the tree afford a complete covering from the wind and rain, and are also manufactured into a kind of cloth, which is generally worn in the country. The Alicondi is said to grow to an immense size; some of them are hollow, and retain great quantities of water, which in that parched climate often affords a most seasonable supply to the inhabitants. The shell, which contains the fruit of the tree, when dried and cleaned, serves for holding wine, oil, and other liquors; and the inner bark, after being well soaked in water, yields a peculiar kind of stuff, stronger and more durable than hemp, which they manufacture into cloth. From the branches of these trees they suspend hollow pieces of wood, to which the bees, with which the country abounds, resort, and from which they derive a supply of honey. The province of Settee abounds with logwood, which forms an article of traffic with the Portuguese, and other Europeans.

Excepting goats, they have few cattle of any kind: those which have been brought from other countries have been so short-lived, as to discourage any attempts to increase the stock. Hogs they have in great plenty; and poultry are said to be so very cheap, that six penny-worth of beads will purchase thirty. Pheasants, partridges, and other wild fowl, are in still greater abundance, and scarcely fetch any price. In hunting they use dogs; but as they cannot bark, they hang wooden clappers about their necks, that they may be able to trace them. This defect in their dogs makes the European dogs highly valued, and they give a great price. The pelican is also to be found here, a bird larger than a swan, shaped like a heron, and of a white and black plumage.

The wild animals are the same as in other countries of Africa, and particularly of the adjoining kingdoms of Congo and Angola. Indeed the wild animals multiply so fast in the woods, that they prey upon and destroy the tame ones. Among the chief, we may enumerate elephants, and lions of a monstrous size, leopards, tigers, wolves, zebras, buffaloes, &c. The country is also infested with a variety of serpents, some of them of a prodigious length and thickness; such as rattle-snakes, vipers, scorpions, and venomous insects of various kinds, both flying and reptile. The most dangerous of these is the ant or pismire, which not only destroys the fruits of the earth, but in the night surround in prodigious swarms men and beasts, and devour them in a few hours, leaving only the bones. Of these animals, the most remarkable and valuable is the elephant. In some provinces he is hunted for his flesh, and his teeth form a valuable article in exchange for European iron, which is afterwards formed into warlike instruments and domestic tools. The zebra is a beautiful animal; his flesh is accounted a delicate food, and his skin is imported into Europe as a valuable commodity. The leopard, another beautiful animal, but very destructive, is frequently hunted. The king assembles the chiefs, and their vassals. When they approach the den or thicket in which the leopard is concealed, they surround it, armed with bows and javelins, while others set traps, or spread nets to catch him alive: then they blow their trumpets, beat their drums, and make a hideous noise till the affrighted animal is dislodged; and being unable to escape through volleys of arrows and darts, he is either killed or forced into the trap, where, in the presence of the prince, he is eagerly dispatched. He is then flayed; the body buried; the gall, which is reckoned a strong poison, is thrown into a deep river, that nobody may be injured by it; and the skin is carried in triumph to the palace, where the feat concludes with singing, dancing, and various amusements. Civet cats are also very numerous, and may be purchased on the easiest terms; and the monkeys are said to bear a greater resemblance, in features and stature, to the human species, than those of other countries.

The lakes and rivers abound with fish, which, in those parts of the country which are sandy and unproductive, form the principal food of the inhabitants. In the rivers, particularly the Banna, the women gather oysters in great quantities, which they cure and preserve for several months. Oysters are also found lying on the coasts, in heaps like small rocks; so that the European sailors can quickly load their boats with them. The natives fish both in the bays and rivers with drag-nets, which have long canes fixed at equal distances, instead of corks, which show when any of the fish are inclosed. These nets are made of the bark of the Alcondi tree already described; which, after undergoing a certain process, they spin like hemp. In the shallow water of bays and rivers, they have an uncommon mode of catching fish with mats made of rushes. Some of these are three hundred yards long, which they set afloat on the surface of the water, with pendent rushes on the sides. These frighten the fish, and make them leap upon the mat, which the fishers draw into a narrow compass like a net, and easily catch them. Large fish, of the size of a grampus, which they call *emboaks*, or sea-dogs, are found to be very serviceable in catching the smaller fish. When this amphibious animal comes to feed along the shore, which he frequently does, he drives whole shoals of the small fish before him, which are then easily caught. If a large one happens to run himself aground, four or five men are employed to set him at liberty, by driving him again into the water; and so sensible are they said to be of the use of this animal, that they will not permit any person to frighten him from the coast.

Like other African states, the arts can scarcely be said to be known among this people. They indeed carry on a variety of trades, and handicraft business, in their own way; but their knowledge is so limited, and their tools are so clumsy and imperfect, that their work is performed in a very rude manner. The commerce of this country formerly consisted chiefly in the sale of slaves. This was accounted its greatest wealth, but was certainly its greatest curse. It has been well remarked, by a writer upon this subject, "that whether you penetrate into those remote countries from the western or the southern coast; whether you trace the Negro or the Hottentot through their various gradations; you constantly find both in the enjoyment of more felicity, and the practice of more virtue, in proportion as you recede from those places where they are subjected to the horrors of the slave trade." Happily for this and the adjoining kingdoms, this nefarious trade is almost terminated. Their chief articles of traffic now are logwood and ivory, both of which they have in great perfection; and the skins of some wild animals. With tin, lead, and copper, they are supplied from the mines of Sundi. They melt the ore on the spot; but as they possess not the art of purifying it from base mixtures, their copper is neither so pure, nor so valuable, as it might be. The Europeans have at different times sent artists to teach them to refine it; but they are either so indocile, or so indolent, that they have not been benefited by their instructions. Their money is nothing more than a slight piece of cloth, of their own weaving, four of which, when stitched together, are worth a penny.

Their dress is generally of their own manufacture, consisting of cloth made from the leaves of the palm, banana, or some similar tree. Persons of the higher rank wear these clothes from the middle to the ankles, but those of the lower only to the knee. They also adorn themselves with beautiful feathers, and not unfrequently suspend a number of little bells, which make a strange tinkling at every movement of the body. Their garments are bound with a rich girdle about their middle. Their necks, wrists, and legs, are ornamented with beads of coral and ivory; with shells of beautiful colours; or with chains of various metals. Over their shoulders they throw a kind of sack knotted, about three-fourths of a yard long, which has a small hole just large enough to admit the hand, and this serves also to hold their calabash, pipes, tobacco, and other provisions. Their heads are covered with a knotted cap, which sits close upon it; and as they never go without arms, they commonly hold a bow, sword, or cutlass, in their hand. The dress of the women is similar to that of the men, except that they wear no girdle, and that their petticoats hang no lower than the knee. Both sexes wear rings of the richer or coarser metals, according to their rank, which they regard as amulets or preservatives from injury; and both paint their bodies with a red wood called *Takeel*, which gives them a frightful appearance.

The government is strictly despotical. The king is master of the lives of all his subjects. Such is their extreme ignorance, that though their kings only style themselves *mani*, or lords of Loango, their subjects not only give them the title of Mokissos, but believe that they are endowed with a supernatural power; that they can raise storms, or withhold rains; render the soil fruitful or barren; enrich or impoverish their subjects; or by a single word send myriads of them to their graves. Hence, it is a capital offence to see them either eat or drink; and treason and rebellion are punished with the cruellest deaths. Their monarchs can bring vast armies into the field. Their warlike weapons consist of the short pike, bow and arrow, sword, and dagger; but the Europeans, and particularly the Dutch, have furnished them with firearms, gunpowder, and balls, besides a variety of kitchen utensils, and several sorts of coarse cloths. Their targets are formed of the hard and thick hides of the dante, and are big enough to cover almost the whole body, and strong enough to repel an arrow or dart.

They entertain various extravagant opinions respecting the nature of the soul, and believe in its transmigration into the bodies of other men, heroes, demons, and guardian spirits. All have great faith in their *Mokissos*, or, as the Portuguese call them, *Fetissos*, that is, the spirit to whom they have been dedicated at their birth; and they are convinced that these spirits have power to inflict punishment, and even death, on those who break any of their vows and engagements. To these spirits they address their worship, and all their invocations. To them they ascribe the power of presiding over the elements, of directing the storms, of regulating the seasons, and of rendering the soil fruitful or unfruitful. Some are accounted of a benevolent, others of a malevolent disposition; some are regarded as friends and protectors, others are dreaded as enemies and destroyers; some they consult about future, and others about past events. They worship them under a variety of images, and pay homage to the good as well as to the bad. If a person enjoys health and prosperity, he flatters himself that his Mokisso is satisfied with his services; if he is in different circumstances, he believes that he is the object of his displeasure, and is led to examine by what means he may regain his favour. But as the mind, even in the grossest superstition, is apt to run from one extreme to another, it is reported that, upon being visited with a dreadful pestilence, they buried their idols, saying, "If they cannot deliver us from this grievous calamity, it is vain to expect any more help from them."

The inhabitants of this, like those of the other countries of the torrid zone, are extremely indolent, being almost incapable of any exertion beyond what is absolutely necessary for the preservation of life. Their soil is so fertile, that, with a little industry, they might be independent of the seasons, and in no danger of being visited by those dreadful famines by which their country is often depopulated. But, besides their aversion to cultivate more ground than what they think sufficient for their subsistence, (a work which is all performed by their wives,) they seem to be naturally formed for abstinence; and a European cannot but be astonished when he sees them contented and happy, singing, smoking, and dancing, in the most alarming scarcity. Like other savages, they are friendly and generous to one another, but passionate and revengeful; very libidinous, and jealous of their wives; fond of the palm wine, and indifferent to that of the grape. Polygamy universally prevails. But women have little encouragement to enter into a state in which they must submit to the most painful mortifications from many rivals; while the violent jealousy of the husband reduces them to the most melancholy servitude. To them is assigned the whole labour of tilling and manuring the ground; of reaping and gathering in the harvest. They are also the only persons employed in grinding the millet and other grain; in making the wines and other liquors; and managing all the household affairs. They must stand at a due distance when the husband eats, and be satisfied with what he chooses to leave them. They must approach him when he enters his dwelling, with words and gestures expressive of joy and respect; and speak to him, and receive his commands, upon their bended knees. They are liable to be dismissed upon the least suspicion of infidelity; and if proved guilty, are subjected to a severer punishment, though the gallant escapes upon paying a fine. But, though this be the slavish state of the women, the children are subjected by a strict law to the condition of the mother. They continue slaves, if the mother be a slave, although the father be free; and they remain free, if the mother be free-born, although the father be a slave. None of the children are allowed to inherit the father's substance; the whole descends to his elder brother or sister, who are obliged to take care of his family till they are able to provide for themselves.

Their laws, though depending chiefly on the will of the sovereign, are milder than those of the neighbouring states, except for the punishment of crimes committed against the king's safety or dignity. Murder is punished with death, adultery with a fine, and theft by obliging the offender to restore what he had stolen, or an equivalent for it, otherwise his hands are tied behind him to a post, and he is exposed to the insults of the spectators. If a bankrupt absconds, his creditors have a right to seize upon one or more of his nearest relations, and to confine him till the debt be paid. One remarkable resolution has been adopted by them. They deny the right of sepulture to all strangers, and cause their bodies to be carried in a boat at least two miles from the shore, and thrown into the sea. The reason of this inhospitable custom is said to be this: A Portuguese gentleman happened to die and be buried. When his remains had been a few months in the ground, a dreadful famine, occasioned by want of rain, obliged them to consult their Mokissos as to the cause of it. They were answered, that a Christian had been interred among them, and that his body must be taken up and thrown into the sea, before they could obtain rain. The people obeyed, and within three days were blessed with what they desired; and ever since they have not permitted any stranger to be interred among them.

Of the history of this country little is known, except that, after having shaken off the yoke of the Congoese, they continued the war for a long time, till they completely established their independence. Afterwards they lived in peace with that nation, and were found in that state when first visited by the Portuguese. They became indeed so closely united with the neighbouring states for the purpose of repressing the incursions of the common enemy, the sanguinary Giagas, that the Portuguese hoped that a conversion of any one kingdom to Christianity would speedily have led to the conversion of all. But the small number of Christian missionaries sent from Portugal, and the hardships they experienced from change of diet and climate, added to their constant fatigue in the duties of their office, rendered them totally inadequate to the great work they had undertaken. Of later years, similar attempts have been made by the French with some better hopes of success.

See Dapper's and Ogilvy's *Africa*, *Mod. Univ. Hist.* vol. xvi. But the latest account is by Proyart, Paris, 1776, drawn up from the memoirs of Belgrade and other French missionaries who settled in the country in 1766. (A. F.)

LOCARNO, in German *Luggarus*, is a town of Switzerland, in the canton of Tesino, agreeably situated at the distance of 300 or 400 paces from the Lago Maggiore, which formerly bathed its walls; the river Magia having deposited the earth which is now interposed between the town and the lake. The town is 72 feet above the lake, and 708 feet above the level of the sea, according to Saussure. It is open and well built, and part of it is built in piazzas, in the form of a crescent with two wings, with the public walk and a row of trees in front. It contains three convents, and a small Franciscan monastery standing on a rock which overhangs the valley. The town is well sheltered on the north, being exposed only to the south-east wind, in consequence of which its climate is as mild as that of more southern latitudes. Population 1500. East Long. 8° 35′; North Lat. 46° 6′ 17″.

LOCHABER. See INVERNESS-SHIRE.

LOCHMABEN, is a royal burgh of Scotland, in the county of Dumfries, and district of Annandale. It is chiefly remarkable for a castle originally built by Robert de Bruce, and situated upon the peninsula which stretches into a loch near the sea. The original buildings appear to have covered about an acre. The walls were 12 feet thick, the outermost enclosing an area of about 13 acres: the whole is surrounded by three ditches at different distances. Between the castle, little of which now remains, and the Kirk-loch, are the vestiges of a more ancient fort.

There are a number of small lochs in the neighbourhood of the town, the largest of which is a fine sheet of water, containing about 15 or 16 different kinds of fish fit for the table. The town is governed by a provost, three bailies, a dean of guild, a treasurer, and nine councillors. It joins with Dumfries, Annan, Kircudbright, and Sanquhar, in sending a member to parliament. Coarse linen was formerly manufactured here, to the extent of 60,000 yards annually, for the English market; but it has now greatly declined. In 1808, the return of profits and professions liable to be taxed in the burgh was only 56*l.*; a proof of the absence of all enterprize; and in the same year, the rents of houses liable to taxation was 1398*l.* There is here a valuable salmon fishing in the river Annan. The population of the burgh and parish, in 1811, was 532 houses, 553 families, and 2392 inhabitants. The burgh contains only about 700 inhabitants. See DUMFRIES-SHIRE.

LOCK is a well known instrument used for securing doors, chests, &c. and preventing them from being opened without a proper key. The simple and common lock, consists of a strong bolt, which is generally fitted into a case of metal, so as to admit of a motion backwards and forwards. The bolt should be inclosed on all sides, in such a manner as to prevent any access to it, except by a small opening, through which the key is to be introduced to withdraw it; which opening should be surrounded inside the lock, by numerous wards or pieces of metal, forming a crooked and interrupted passage, to prevent the introduction of any improper instrument or false key, to pick the lock and withdraw the bolt. The proper key has an opening in its bit, which permits it to pass through and turn round among the wards, without meeting with any obstruction till it comes in contact with the bolt, which it moves sufficiently to allow it to pass by and be withdrawn through the key-hole, after having made a complete revolution. In this lock, there is nothing to prevent the bolt from being forced back, if any access can be had to the end of it, without the necessity of introducing any instrument by the key-hole. To obviate this difficulty, some locks are furnished with one or more pieces of metal called tumblers, (moving on a fixed centre pin), which fall into notches cut in the back of the bolt, and prevent the possibility of its being withdrawn without first raising up the tumbler out of the notches in the bolt, leaving it at liberty to move by the action of the key. The tumblers are raised up by a part of the bit of the key, and must be so shaped as to be raised quite clear of the notch in the bolt, before the key begins to act upon the bolt to move it backwards. The principal security in these locks, depends upon the intricacy of the wards preventing any key being introduced or turned round in them, which has not the requisite opening in it to allow it to pass; but this difficulty is very easily overcome by making a key with a plain bit, and of sufficient dimensions to enter the opening of the key-hole; then covering its surface with some soft and plastic substance, (as wax, for instance,) which will receive the impressions of the wards, and by that means the bit may be cut out with proper openings, so as to enable it to turn round and move the bolt. Another insecurity in the common lock, arises from the limited number of variations that fixed wards will admit of, without being so much alike, that the key of one lock will pass through the wards of another. Indeed, any ill-disposed person might provide himself with a bunch of keys, called skeleton keys, which would open almost any lock constructed upon the above principles. A skeleton key means one which is cut out, so as to leave only the extreme part of the bit entire which moves the bolt, the other part being reduced to a thin piece, of just sufficient strength to move the bolt without breaking. It will easily be seen, that such a key would not be likely to meet with any interruption from wards, as very little solid metal is left; the direction of the solid metal should be different in every one, some inclined, some cut away, leaving only a small bar of metal at the bottom, others at top, &c. so that out of a dozen such keys, a person might find one that would pass through almost any set of fixed wards.

In order to produce a lock free from these objections, many ingenious mechanics have turned their attention to the subject of lock-making. In fact, the object of securing property from the depredations of others is so important, that few instruments have had more pains and ingenuity bestowed on them than locks.

Most of the contrivances for locks were supposed to possess some particular advantage, such as strength to resist violence, or security against being picked. Some speculators have acted upon a different principle altogether—that of attaching an alarm, a large bell, a species of fire-arms, &c. to a lock, in such a manner that an attempt to violate the lock would set the bell a-ringing, or discharge the fire-arms; thereby causing a great noise and confusion, that the depredator might not escape. Our limits will not permit us to enter into the details of all the schemes that have been proposed to give security to locks; but we shall notice principally such as have come into use by their own recommendation.

In Plate CCCL., we have given drawings of those locks which we consider most worthy of notice. Fig. 1. of the plate shows the outside of one of Mr. Bramah's locks, as adapted to a desk or box, which, from the many advantages they possess, have become very general. Mr. Joseph Bramah obtained his first patent for locks on this principle in the year 1784, but has since made many valuable improvements, and obtained subsequent patents for them. Figs. 1, 2, 3, 4, and 5. of the plate represent the detailed parts of a lock according to the last and most improved construction. AA, Fig. 1. shows the bolt. It is formed like two hooks rising out of a bar of metal, which slides backwards and forwards upon the surface of the plate BB, the edge of which is turned up at right angles, and has openings through it for the hooked parts of the bolt to move in. The bolt is guided in its motion endways, by sliding through square holes in the edge pieces of the lock, which are rivetted to the main plate. A plate of metal C, is secured to the edge pieces by two screws, 1, 1, and two steady pins. This plate prevents the bolt from rising up out of its place, and has a cylindrical projection D, on its surface, which contains all the mechanism of the lock, and protects it from external injury. The projection D is neatly finished; and when the lock is put on a desk or box, its end projects through the wood a small distance, forming a very neat escutcheon, having the key-hole in its centre. Fig. 2. shows a perspective view of the mechanism of the lock withdrawn from its case D. It consists of a barrel or cylinder E, pierced with a cylindrical hole through its centre. The inside of the hole has six narrow grooves cut through its length, and in the direction of radii, from the centre towards the outside of the cylinder E; but leaving a sufficient strength all round. These grooves are fitted with small sliders, of the form shown at *a a*, Fig. 5, being split in thickness, and forced into the grooves, so as to move up and down therein with a slight friction, that they may not fall down by their own weight. They have small notches, 2, 3, 3, cut in the back part, the use of which will be hereafter explained. The lower part of the opening through the cylinder E is closed by a circular plate of metal F, Fig. 5. fixed by two screws. It has a pin, *b*, projecting up from its surface, which forms the centre for the pipe of the key to slide over. There is also another short circular stud, *c*, on its under side, which enters into the curved opening *d* in a part of the bolt at Fig. 4. The stud *c* revolves with its plate F and the cylinder E; and, by the form of the opening *d*, moves the bolt backwards and forwards. It now remains to show how the cylinder E is prevented from being turned round, so as to move the bolt without the proper key being introduced. The cylinder has a circular groove or notch cut round its circumference at *e e*, to such a depth as to intersect the straight radii or grooves some distance, but still leaving a ring of metal round the hole through E, or it would fall into a number of pieces. Into the notch *e e* a thin circular plate of metal, in the form of *f f*, Fig. 2. is introduced, having a hole through its centre the same size as the bottom of the notch. It is divided into two halves, to enable it to go round the cylinder, as seen at *f f*, Fig. 3. and dotted in Fig. 2: and when the mechanism of the lock is introduced into the case D, the plate *f f* is held fast, and secured by two screws, 4, 4, (Figs. 1. and 3.) to the plate C, in which situation the cylinder E, with its appendages, can be turned round by its key, but cannot move up or down, the plate *f f* preventing it.

We shall now explain how the key operates to turn the cylinder E, and move the bolt AA. The plate *f f*, Fig. 2. has six notches, 5, 5, 5, &c. filed round the inside through these notches. The sliders *a a* can move up and down when the plate is in its place; but cannot move round with the cylinder E in a circle unless the sliders are all depressed in their grooves, so that the deep notches, 2, Fig. 5. of all the six sliders come into the plane of the circular plate *f f*, as shown by the section, Fig. 3; in which state the cylinder, with its sliders, may be turned round, in order too shoot the bolt. Now, if any one or more of the sliders are pressed too low, or not long enough, to come into the plane of *f f*, the cylinder cannot be moved round, because they are intercepted by the edges of the notches 5, 5. In the plate *f f*, the whole number of sliders are pressed up, or caused to rise in their grooves, as far as the top of the cylinder E, by a spiral spring, 6, coiled loosely round the pin *b*, Fig. 5. This forces up a small collet, 7, on which the steps 8 of the sliders *a a* rest. The first locks were made with a separate and independent spring to each slider; but it is a very great improvement the introduction of one common spring to raise up the whole number; because, if a person attempts to pick the lock by depressing the sliders separately by means of any small pointed instrument, and by chance brings two or more of them to the proper depth for turning round, should he press any one too low, he has no means of raising it again without relieving the spring 6, which immediately throws the whole number of sliders up to the top, and destroys all that had been done towards picking the lock.

One of the latest improvements Mr. Bramah made in his lock, and one which very much increases the difficulty of picking, and its consequent security, was the introduction of the two false and deceptive notches cut in the sliders, as seen at 3, 3, Fig. 5. It was found that, in the attempt to pick this lock, an instrument was introduced by the key-hole to force the cylinder E round. At the same time that the sliders were depressed by separate instruments, those sliders which were not at the proper level for moving round were held fast by the notches 5, 5, in the plate *f f*, bearing against their sides; but when pressed down to the proper level, or till the notch 2 came opposite the plate *f f*, they were not held fast, but were relieved. This furnished the depredator with a means of ascertaining which sliders were pressed low enough, or to the point for unlocking. The two notches 3, 3, in the sliders, are sometimes cut above the true notch 2, sometimes below, and at other times on each side; and are not of sufficient depth to allow the cylinder E to turn round, but only to mislead any one who attempts to pick, by his not knowing whether it is the true notch or otherwise, or even whether the slider be higher or lower than the true notch.

In the present state of Mr. Bramah's lock, as we have just described it, we consider it almost impossible to pick it, or make a false key from the lock alone. Another recommendation to it is, the smallness of the key; for having so small a bit projecting from it, it may be carried about the person of the owner without inconvenience. The form of the key is shown at Fig. 6. It has six notches cut round its edge, of different depths, to press the slider down each a proper quantity. It has also a small projection from its side at 10, which enters the notch 11, (Fig. 2.) in the cylinder E, to turn it round and throw the bolt.

The bolt of this lock is prevented from being forced back when locked by the stud *c*, on the bottom F of the cylinder, Fig. 5. coming into a direct line with its centre of motion, as shown at *c*, Fig. 4. when no force, however great, applied to drive the bolt back, would have any tendency to turn the cylinder E round. This prevents the mechanism from being injured, although it is very delicate. These locks are sometimes made with eight or more sliders, in which case the combination becomes greater, without much danger of being deranged by the ordinary use of the lock, being made of durable materials. We have entered somewhat minutely into the description of Bramah's lock; but as it is in pretty general use, and very ingenious in its construction, we thought it would not be unacceptable to our readers.

In Fig. 7. of the plate we have represented a tumbler lock in a very complete state, as invented by Mr. Robert Baron, and for which he obtained a patent about the year 1778. AA is the bolt, which is guided in its motion endways, by passing through a mortice in the piece D at one end; and also through the edge of the main plate B, which is bent up at a right angle. The bolt is filed away on the under side, and only bears at the ends, to allow room for the two tumblers 1, and 2, to lie beneath. It has four notches cut through it, which are connected by a groove in the direction of its motion, for the studs 1, and 2, of the tumblers to act in. The drawing represents the lock in its locked state, (or with the bolt shot,) in which situation the studs 1, and 2, on the tumbler *a*, rest in the notches of the bolt, and prevent its being forced back, without first raising the tumblers upon their centre of motion at *a*, so that their studs come out of the notches into a line with the groove in the bolt, in which state the bolt can be withdrawn. The tumblers lie over one another, and are raised to the proper height, for the bolt to pass by different steps formed upon the bit of the key, below the part which acts upon the bolt to shut it. These steps require a very great nicety in their adjustment; for if any one of them is too short, it will not raise its corresponding tumbler high enough to pass in the groove. On the contrary, if any one of the steps is too long, it will raise it into the upper notch above the groove in the bolt, and prevent its motion equally both ways. It is very difficult to make a false key to these locks. As the tumblers are not stationary, no impression can be taken, to apprise the person whether his key is too long or too short, nor even how many tumblers there are in the lock, which may be varied from one to four or five. The greater the number of tumblers, the greater will be the difficulty of opening or picking the lock; but when more than two tumblers are used, the bolt should be made longer in proportion than is shown in the drawing, to give room for the different notches, without materially weakening the bolt. When the lock is unlocked, the studs 1, and 2, of the tumblers rest in the notches 3, and 4. The tumblers are forced downwards by the action of a spring applied separately to each, as shown by the dotted line *c c*. A strong spring *d d* is applied at the back of the bolt, which has a beak turning downwards, and resting in a rounding notch made in the bolt, in such a manner as not to prevent the motion of the same, but only to cause a sufficient resistance to keep the bolt in its required place; for, should the lock be placed in a situation where the bolt was in a perpendicular direction, and the studs of the tumblers be raised out of the notches in the bolt by any improper means, the bolt would fall down by its own weight, and become unlocked, having nothing left to support it. The spring *d d* prevents this from taking place. Mr. Baron generally furnished his locks with a system of wards, to prevent the introduction of picklocks as much as possible; and we are of opinion that there is no lock which surpasses this either in cheapness or durability. And if the same principle is carried sufficiently far, by making a number of tumblers, the difficulty of picking such a lock would be almost impossible. The very general use of this lock is the best proof of its merit.

Figs. 8, and 9, represent a contrivance called a fly tumbler. It is generally applied to locks such as we have just described; and we are informed it was first introduced by Mr. Baron as an addition to his lock. The object of this contrivance is to prevent any person from opening the lock, even though the key were left in it, as it requires a particular movement of the key to unlock or withdraw the bolt. AA represents part of the bolt of the lock. D, the edge of a piece of metal, which guides its motion. B, the key, turning round upon a fixed pin projecting up from the main plate of the lock. C is a piece of metal, called a fly tumbler, which moves upon the screw *a*, as a centre of motion, upon the bolt; it is formed to a curve at the back part, against which the spring *b b* bears, and tends always to bring the piece C into the position shown in Fig. 9, in which state the bolt is represented in an unlocked position. If the key B is introduced into the lock, and turned round in the direction of the arrow, it passes by the end of C without producing any effect on the bolt; but when it meets with the step 4 in the bolt, it shoots or throws it forwards into the position seen at Fig. 8, which also shows the key B, in the act of withdrawing or unlocking the bolt, by the intervention of the piece C; the bolt itself being cut away, so that the bit of the key will not touch it in any part. The secret of opening this lock consists in the manner of bringing the key into the position shown in Fig. 8; for if it is left in the key-hole, a person unacquainted with it may turn it round in either direction, without affecting the bolt, for the piece C will be moved out of the way by the bit of the key in passing, and will return always to the position C, Fig. 9, by the action of its spring *b b*. To effect the unlocking, the key must be turned round with caution in the same direction as for locking, (that is, in the direction of the arrow,) until the angle 1 of the piece C escapes over the corner of the bit of the key, and the beak 2 rests upon it, as in Fig. 8, in which situation, if the key is turned in an opposite direction, the piece C will be moved backwards, carrying the bolt A, to which it is fixed, along with it, so as to be unlocked. But if the key were moved a very little farther in the direction of the arrow than to allow the angle 1 to escape, the beak 2 would escape also; in which case the key will turn round, but not act upon the bolt.

Figs. 10, and 11, represent a lock invented by Thomas Ruxton of Dublin, and for which he procured a patent in 1816. The object he had in view was of considerable importance—that of giving information to the owner of a lock if any attempt had been made to violate it, either by introducing a false key or a picklock. AA shows the bolt of the lock, lying upon the main plate B, and passing through the turned-up edge *n n*, to guide it in its motion; the other end moving in the piece D. Only one of the tumblers is seen in the drawing at 1, the other being concealed from view. They turn on a centre pin at *a*, rising from the main plate, and are acted upon by separate springs, one of which is seen at *c c*. In this lock, the tumblers, instead of having a stud to enter a groove in the bolt, like Baron's, have an opening, *b*, into which the projecting leaf *d*, on the bolt, must pass before it can be withdrawn. The lock is represented in the figure as in a locked position, in which situation the leaf *d* rests upon a solid part of the tumblers, and prevents the descent of the bolt, unless all the tumblers are raised by the different steps on the key, or otherwise, till their openings *b* correspond, and form a clear opening, into which the leaf *d* can enter. To allow of the bolt's motion when acted upon by the key, a notch is cut in the edge of the bolt, so as not to interfere with the centre pin *a* of the tumblers. The mechanism in this lock, for detecting any attempt at violation, is as follows: A notch or opening is made through the turned edge *n n* of the main plate. This opening is exactly filled up to the surface by the upper end of a small bolt E, (which the patentee terms a detecting bar.) It is guided at the lower end by passing under a square staple *e*; and its weight is supported by bearing against the end of a spring F. This spring is screwed fast at the end G against the surface of the main plate; but it is raised up to the other, and supported by bearing on the edge of a small plate *i*, turning upon pivots formed at its under edge, which enter small holes in the plates D and *m*. When the plate *i* is turned up perpendicular to the main plate, the end F of the spring rests upon it; and the detecting bar E is supported or borne up by the end of the same spring. In this situation the lock is in an undetected or ordinary state, as shown at Fig. 10. But if any improper instrument or false key should be introduced through the key-hole, for the purpose of raising the tumblers to open the lock, and should raise any one of the tumblers a small distance beyond its proper position for the leaf *d* on the bolt to enter, the curved tail, or projecting piece *g h*, on the tumbler, would come into contact with the plate *i*, and move it upon its pivots out of the perpendicular position, when the spring F would turn it down flat against the main plate of the lock, as shown by the edge view Fig. 11; (which explains the situation of the parts after an attempt has been made;) and the detecting bar E, losing its support, would fall by its own weight, leaving a square opening in the face of the plate *n n*, which could not escape the observation of the owner, the first time of opening the drawer, and thereby inform him that an improper attempt had been made to open the lock. The lock represented in the drawing is adapted for a drawer, as it is necessary the detecting bar should stand perpendicular, in order that it may fall by its own weight when the support is removed. But if the lock is required for a door, a spring must be applied to draw back the detecting bar, as it would then be in a horizontal direction, and would not fall by its own weight. This lock is defended by a system of wards and plates, fixed so as to prevent any access to the mechanism, except through the channel in which the key moves.

A patent has lately been granted to Mr. Jeremiah Chubb, of Portsea, for a lock which he calls a *detector lock*, having had the same object in view as Mr. Ruxton; but we consider Mr. Chubb's as much more perfect and certain in its action, being well contrived both in the locking and detecting mechanism. If a false key or picklock be introduced into Chubb's lock, it not only apprizes the owner that it has been attempted, but at the same time throws a catch into the bolt, which detains it in such a manner as not to allow it to be moved, even by its proper key; so that the owner finds out, on introducing the key, that an attempt has been made to pick the lock. In such case, he introduces an instrument, or key, called a regulator, which places the parts of the lock in a situation to be operated upon by its proper key, at the same time it returns the catch, and liberates the bolt. This regulation would be as difficult to effect without the aid of the regulator key, as it would be to open the lock without its proper key, as the regulator must act upon and raise all the tumblers to one certain point, before the catch which detains the bolt can possibly be withdrawn.

Figs. 12, 13, 14, and 15, will serve to explain the construction of Chubb's patent detector lock. A, Fig. 12, is the bolt; BB, the main plate, which is turned up at one edge, *n n*, and has a mortice in it to guide one end of the bolt; the other end is guided by sliding upon a square part of the pin *a*, which also forms the centre for the tumbler C to move upon. They are situated one over the other upon the surface of the bolt, and have openings made in them at *b*, for the stud *d* of the bolt to enter when it is withdrawn; the openings *b* are only just wide enough to allow the stud to move through; so that if any one or more of the tumblers is raised too high, or not high enough, the stud cannot enter the opening to withdraw the bolt, each tumbler is pressed towards the pin 14 of the key, by separate springs, *c c*. The lock, thus far, does not differ materially from Mr. Ruxton's in its principle of action; but it now remains to explain the detecting mechanism, which consists in the introduction of a lever or detent *q e*, moving on a fixed centre pin in the main Plate at 1, the end *q* projecting downwards, so as to come very near the upper side of the tumblers, when they are raised up in order to shoot the bolt, while the other end *e* of the lever has a hook which comes down very near the bolt. The lock is represented in the drawing as in a locked position, the detecting mechanism being out of action; but if any improper instrument is introduced into the lock for the purpose of raising the tumblers to get back the lock, and any one or more of the tumblers should be raised the smallest quantity too high, such tumbler would come into contact with the beak *q*, of the detecting lever, and move it upwards a short distance, till the point of the triangle 2 at the end *e* passes by the angle of the spring 3, in which state, its hook *e* would be instantly thrown into a notch 4, in the bolt, and detain it, as shown by Fig. 13. in which position, the proper key of the lock A, Fig. 15. will not be able to extricate it, but it will require the aid of the regulator key B, to be introduced by the keyhole and turned partly round, so that the different steps upon its bit may raise up the tumblers till their notches 5 correspond and come opposite the small stud 6, upon the regulator bolt, (which is seen separately at E, Fig. 14.) in which situation, the regulator key will slide the bolt endways, and by its inclined plane, 7, acting under the end of the hook *e* of the detecting lever, will return it to the position seen in Fig. 12. when the proper key will raise the tumblers and shoot the bolt without interruption. The regular bolt, E, lies directly beneath the main bolt, and is guided by sliding upon the pin *a* in the same manner as the bolt A, it is not acted upon by the proper key, because the pipe of the key projects lower than its bit, as seen in the key A, Fig. 15. but in the regulator key, the bit projects lower than the end of the pipe, which makes it take hold of the regulator bolt, and move it so as to return the detector lever beyond the angle of the spring 3, and out of the notch 4 in the bolt.

Figs. 16, and 17, of the Plate, represent a lock, called a combination padlock, since it does not require a key to open it, but only a particular combination of letters, forming a word or otherwise, which word ought to remain a secret with the owner; but if it should by any chance be discovered, he has a very ready means of changing it even to many thousand different combinations, which makes it almost impossible to be opened without a knowledge of the word for which it happens to be adjusted. Fig. 16. shows the lock in an unlocked position, the staple, A, being turned up on its centre of motion. It consists of a number of circular rings of metal placed side by side upon a tube of the same diameter, at the inside of the rings, so that all the rings can turn round quite freely, and independent of each other. Fig. 17. shews the details of the lock on a larger scale, only one of the rings being drawn to make it more clearly understood. BB is the tube on which the rings turn, soldered or otherwise firmly fixed by one of its ends, to the end plate C of the lock, which also carries the centre pin *a* of the staple A. The tube B has a groove, 1, 1, made in its side for the studs 2, 2, to move in, which studs project from a round bolt E, sliding endways within the tube B; the end *e* of the bolt is formed into a screw, which enters a hole in the end plate D, Fig. 16. and unites them firmly together. The rings have each a notch in them, as at 3, of sufficient size for the studs 2 to move in, when placed in a a determined position, the staple, A, is prevented from being lifted up when the lock is fast by the circular pin, *b*, entering a hole in the end plate D; but if all the rings are turned round to one determined situation, their notches 3 all coincide, so as to allow the studs 2, 2, to enter them, which is done by pulling the end plate D out, its bolt E, with its studs will move endways clear of the pin *b*, and permit the staple A to be raised up, as in Fig. 16; two marks, *m*, *m*, are made on the edges of the end plates CD, and the letters on the circumferences of the rings are brought for a particular word in a line between the said marks, as shewn in Fig. 16. where the letters form the word *lock*, when the notches, 3, are in a line, and the end plate, D, can be withdrawn sufficiently to relieve the staple. We will now explain how the word can be altered at the pleasure of the owner: When the lock is in the position, Fig. 16. turn the plate D round, and it will unscrew from the bolt, E, and the rings may be slipped off endways, one by one, by bringing their notches, 3, over the studs 2; each of the rings is formed out of two concentric rings, 5 and 6, Fig. 17. the outer one, 5, having the letters of the alphabet imprinted on its circumference, it has also a number of small notches cut in its inner circle, corresponding in place with the letters on the outside; the inner ring, 6, which slides upon the tube B, has a small projection from its outside, which enters any one of the notches in the outer ring; it has also a large notch 3, cut from the inside, to allow the studs 2 to pass, and is turned out larger at the backside round the centre, for the studs to turn round in when the lock is fastened.

By this arrangement, whatever letter on the outside of the ring 5 is placed to correspond with the notch 3 in the inner ring, 6, must also be placed in a line with the marks *m m*, Fig. 16. to enable the lock to be opened; for, if any one of the rings is not placed with the proper letter opposite the marks, the corresponding stud 2 will not enter its notch 3, and consequently, the bolt E cannot be withdrawn so as to relieve the staple A.

The different combinations that a lock of the above description will admit of are immense. Since each of the rings admit of 24 positions, with respect to the notch 3, only, the owner of such a lock must be careful not to forget the opening word he last placed it at, as in such case it would require to be broken open by force, since there is no means of discovering the word except when the lock is open.

The subject of locks is so very extensive, that it would far exceed our limits to give a description of all the different forms and arrangements that have been proposed by various persons. (J. F.)

LOCKE, John, an eminent English philosopher and valuable writer, was born at Wrington, near Bristol, on the 29th of August, 1632. His father was a man of considerable fortune, and bestowed great pains on the education of his son. When he had arrived at a proper age, young Locke was sent to Westmінter school, where he continued until the year 1651, when he was entered a student of Christ-Church College, Oxford. Here he distinguished himself by his application and proficiency in his studies; but frequently expressed his dissatisfaction with the method pursued at this university, where the Aristotelian philosophy was exclusively taught. The writings of Descartes first gave him a relish for the study of philosophy. In 1655, he took his degree of B. A. and in 1658, that of M. A. For some time he devoted himself with great zeal to the study of physic; but his constitution was too delicate to admit of a laborious application to the medical art. In the year 1664, he went abroad in the capacity of secretary to Sir William Swan, who was appointed envoy from the English court to the Elector of Brandenburg, and some other German princes; but within less than twele months he returned to England, and resumed his studies at Oxford. In 1666, an accident introduced him to the acquaintance of Lord Ashley, afterwards Earl of Shaftesbury, who was so much pleased with him, that he invited him to his house, and ultimately prevailed upon him to make it his constant residence. While in this situation, Mr. Locke had an opportunity of rendering most important medical service to his lordship; who so highly esteemed his abilities and worth, as to consult him confidentially in his most intimate family concerns.

Through this nobleman Mr. Locke was introduced to the conversation of some of the most eminent men of that age, which contributed to improve his knowledge of the world. In the year 1668, he accompanied the Earl and Countess of Northumberland on a tour to France; and upon the death of the earl, he returned to England with the countess, and again took up his residence at Lord Ashley's, who was at that time chancellor of the exchequer. That nobleman having, in conjunction with other lords, obtained a grant of Carolina, Mr. Locke was employed to draw up the fundamental constitutions of that province.

In 1670, and the following year, Mr. Locke began to form the plan of his *Essay on Human Understanding;* but his other employments and avocations prevented him from making any great progress in that work. About this time he became a member of the Royal Society. In 1672, Lord Ashley having been created Earl of Shaftesbury, and raised to the dignity of Lord High Chancellor of England, Mr. Locke was appointed secretary of the presentations, which place he held until his lordship resigned the great seal, in the following year. The earl, however, who was still president of the Board of Trade, appointed Mr. Locke secretary to the board; but the commission was dissolved in the year. 1674. In the following year he was admitted to the degree of bachelor of physic.

In the summer of 1675, Mr. Locke, being apprehensive of a consumption, made a tour in France, and resided for some time at Montpellier. From thence he repaired to Paris, where he formed an acquaintance with several eminent literary characters. In 1679, the Earl of Shaftesbury having been again restored to favour at court, and made president of the council, he sent to request that Mr. Locke would return to England, which he accordingly did; but within six months that nobleman was again displaced; and in 1682 he was compelled to retire to Holland, to avoid a prosecution for high treason. Mr. Locke followed his patron: and even upon his lordship's death, which happened soon after, he did not think it safe to return to England. Indeed, he had not been absent twelve months, when he was accused at the English court of having written certain tracts against the government, which were soon afterwards discovered to be the productions of another person. Through the influence of the court, however, Mr. Locke was deprived of his place of student in Christ-Church, in November, 1684.

In the year 1685, when the Duke of Monmouth and his party were making preparations in Holland for his rash and unfortunate enterprise, the English envoy at the Hague demanded that Mr. Locke, and eighty-three other persons, should be delivered up to him by the States-General; which obliged him to lie concealed nearly twelve months, till it was sufficiently known that he was inncocent of any concern in that business. During his residence in Holland he formed a literary society at Amsterdam, of which Limborch, Le Clerc, and several other learned men, were members. Towards the end of the year 1687, he finished the composition of his great work, the *Essay concerning Human Understanding.* Of this work he also made an abridgment, which his friend Le Clerc translated into French, and inserted in one of his *Bibliotheques*. During the period of his concealment, he wrote his first *Letter concerning Toleration*, in Latin, which was printed at Gouda, in 1689, under the title of *Epistola de Tolerantia;* and was soon afterwards translated into Dutch and French.

The Revolution, in 1688, opened the way for Mr. Locke's return to his native country; and he accordingly came over to England in the fleet which conveyed the Princess of Orange. Soon after his return, he endeavoured to procure his restoration to the student's place in Christ-Church; but when he found that the society resisted his pretensions, and would admit him only as a supernumerary student, he desisted from urging his claim. As a sufferer for revolutionary principles, he might perhaps have obtained some lucrative post without much difficulty; but he was satisfied with that of commissioner of appeals, (worth about 200*l.* a year,) which was procured for him through the interest of Lord Mordaunt. About the same time he was offered an appointment in a diplomatic character: which he was obliged to decline, on account of the infirm state of his health.

In the year 1690, he published his celebrated *Essay concerning the Human Understanding*, in folio; a work which established the author's reputation as the most profound and ingenious philosopher of the age. Notwithstanding the efforts of the University of Oxford to discourage the reading of it, this work was eagerly perused; and having been translated into Latin and French, the fame of the author was spread throughout every part of Europe. The fourth edition, in English, with alterations and additions, was printed in the year 1700; and numerous editions have since passed through the press. In 1690, Mr. Locke also published his *Second Letter concerning Toleration*, written in answer to Jonas Proast, a clergyman of Queen's College, Oxford, who had made an attack upon his first letter. In the same year appeared his *Two Treatises on Government*, in which he refutes the principles of Sir Robert Filmer. In 1691 he printed an occasional treatise, entitled, *Some Considerations on the Consequences of lowering the Interest and raising the Value of Money*. In consequence of the publication of this and some other pieces on the same subject, he was frequently consulted by the ministry, relative to the new coinage of silver, and other topics. Having found that the air of London had a prejudicial effect upon his health, he was obliged to quit it occasionally, especially during the winter season; and having received an offer from Sir Francis Masham, of apartments in his house at Oates, in Essex, he was induced to reside there during the greater part of the remainder of his life.

In 1692, Mr. Locke published *A Third Letter for Toleration, to the Author of the Third Letter concerning Toleration;* and a reply having appeared, about twelve years afterwards, by his old antagonist Jonas Proast, he began *A Fourth Letter*, which was left in an unfinished state at his death, and published among his posthumous pieces. In 1693, he published his *Thoughts concerning Education*, which he greatly improved in subsequent editions. In 1695, he was appointed one of the commissioners of trade and plantations, which engaged him more in public business, and obliged him to reside more in London than he had done for some time past. In the same year he published his treatise on *The Reasonableness of Christianity, as delivered in the Scriptures.* This book having been attacked in a scurrilous manner, by Dr. Edwards, in his *Socinianism Unmasked*, Mr. Locke was induced to publish a first and a second *Vindication of the Reasonable-*

ness of Christianity, &c. This controversy was scarcely ended, when he was drawn into another, in consequence of the use which was made of his writings by Mr. Toland, and in several treatises published by some Unitarians, who endeavoured to support their principles by the authority of Mr. Locke. His antagonist, upon this occasion, was Dr. Stillingfleet, Bishop of Worcester, who, in his *Defence of the Doctrine of the Trinity*, published in 1697, censured some passages in the *Essay concerning Human Understanding*, as tending to subvert the fundamental doctrines of Christianity. Mr. Locke immediately published an answer to this charge; and the controversy, after having been maintained for some time, was at length terminated by the death of the bishop.

Mr. Locke's constitutional complaint, the asthma, had now so much impaired his health, that he determined to resign his post of commissioner of trade and plantations, as he found himself no longer able to discharge the duties of it. From this time he continued to reside altogether at Oates, and devoted the remaining years of his life wholly to the study of the sacred Scriptures. He died on the 28th of October, 1704, in the seventy-third year of his age.

Mr. Locke possessed a great knowledge of the world, and was intimately conversant with public business. His natural temper was rather irritable; but, in general, he was remarkable for the ease and politeness of his behaviour. In conversation he was affable and good-humoured; and he had preserved many agreeable anecdotes, which he related in a very natural and pleasant manner. He was warm and steady in his friendships, and charitable to the poor. He was naturally active, and took as much exercise as his health would permit. Sometimes he diverted himself by working in the garden, and was fond of walking; but being prevented by his asthma from taking much of that exercise, he used to ride out after dinner, either on horseback, or in an open chaise. There was nothing peculiar in his diet; but his common drink was only water, which he thought was the cause of his life being prolonged to such an age, notwithstanding the weakness of his constitution.

As a philosopher, Mr. Locke has great merit. Sensible of the imperfections of the scholastic philosophy, he resolved to discard all previous theories, and to institute a new inquiry into the operations of the human mind, and the sources and limits of our knowledge. He rejected the doctrine of innate notions, and ascribed all our ideas to sensation and reflection. Hence he was led to enter into a minute investigation of the phenomena of mind, of the nature of our ideas, simple and complex, and of the operations of the understanding in forming, distinguishing, compounding, and associating them. On the errors resulting from the imperfections of language, he has made some excellent remarks; and also on the necessary limits, the use, and abuse of human knowledge. As an original inquiry into the operations of the understanding, resulting from a long and attentive observation of the phenomena of mind—as an attempt to free the territory of philosophy from idle controversy and vain subtilty, and to direct the attention of philosophers to a diligent and candid investigation of truth—his *Essay* is universally allowed to be a work of inestimable value; and his doctrines have certainly had a great influence in giving a direction to metaphysical speculation, both in this country and in France. On the other hand, he has been thought to have attended too exclusively to the matter of our knowledge, to the neglect of its forms; and he has been charged, moreover, with inconsistency, in supporting his doctrine of the empirical origin of our ideas by a multitude of unsatisfactory proofs; while, at the same time, he maintained the possibility of demonstrating propositions which lie beyond the sphere of experience.

The other works of Mr. Locke, especially his Treatises on Government and Education, and his Letters on Toleration, contain a variety of observations at once philosophical and just; and they breathe a spirit of liberal thinking, which entitle them to the approbation of every enlightened friend of civil and religious freedom.

His whole works have been collected, and frequently reprinted, in three vols. folio, and four vols. 4to. See the Life prefixed to the 4to. edit. of Locke's works; *Biog. Brit.*; Enfield's *Hist of Phil.*; Aikin's *Gen. Biog.*; Le Clerc's *Bibliothèque Choisie*; Tenemann's *Abhandl. über den Empirismus in der Philos.* in the third volume of his translation of Locke's works; G. E. Schulze, *Kritik d. theoret. Philos.* (z)

LOCKS. See NAVIGATION, *Inland*.

LOCLE is a large town of Switzerland, situated in a high valley, among the mountains of Neuchatel. This valley, which is about two leagues long, is traversed by the little river Bied, whose waters have no other mode of escaping but through the rents of the rocks. Locle, as well as the village called Chaux de Fond, which, though two leagues distant, is connected with it by a range of pleasant cottages, consisting of a great number of houses skirting both sides of the road.

These two villages have been long remarkable for the mechanical skill and ingenuity of their inhabitants, and contain each a population of about 7000, consisting of French, Genoese, German, and natives, who are principally employed in the manufacture of watches; and, notwithstanding the high price of provisions, the movement of a watch can be purchased at from 8s. 6*d.* to 10*s.*, and a silver watch for little more than a guinea. About 40,000 watches are said to be made annually in this place. Lace is also manufactured at Locle and in the neighbouring valleys. There are several thousands of women, who gain from six sols to three livres per day. The subterraneous mills of Roches, near Locle, about 100 feet below the ground, are regarded as great curiosities. The river Bied, whose waters are lost in this place among the cleft of the rocks, have hollowed out large subterraneous caverns. Two brothers of the name of Robert had the boldness and skill to erect in these deep caverns three mills, situated vertically, the one below the other. Strangers descend into this abyss by the light of lamps, for the purpose of seeing these works of industry. Near these mills is the *Rocher Fendu*, a remarkable rent in the rocks, through which, in 1779, the inhabitants of Locle had formed the plan of forming a road, which should lead directly to that part of Francne Compté which now forms the department of Doubs. The view into France through this narrow aperture is reckoned extremely curious. There are circulating libraries in these villages; and the houses are not only plastered, white-washed, and clean without, but furnished with a degree of elegance which appears very remarkable in such a sequestered spot. See Ebel's *Manuel du Voyageur en Suisse*, tom. iii. p. 384; and Coxe's *Travels in Switzerland*, vol. ii. p. 123.

LOCUS, in Geometry, is the line in which a point must be situated in order to satisfy some proposed condition. Thus, if it be required that a point shall be equally distant from two given points; its *locus* will be a strait line given by position, which will bisect the line that joins the points, and be perpendicular to it. Again, if a point is to be equally distant from two straight lines given by position; its locus will be a straight line given by position, which will bisect the angle contained by the two lines.

The theory of *Loci* is of great importance in the resolution of many geometrical problems: for if from the conditions of a problem we can determine two lines in which a point is situated, their intersection will manifestly give the position of the point. For example, Let it be required to find a point that shall be equally distant from two straight lines given by position, and also equally distant from two given points, supposing them all in the same plane. The first condition will be satisfied, if the point sought be any where in the straight line that bisects either of the angles which the one given line makes with the other; and the second will be satisfied, if the point be any where in a straight line that bisects at right angles the line which joins the given points; therefore it must be at the intersection of these two lines, and by drawing them, that is, by describing the *Loci* which expresses the conditions of the problem, the position of the point sought may be determined.

For an account of the ancient geometers on *Loci*, see ANALYSIS, and also GEOMETRY, in its history. On the theory of geometrical *Loci*, consult *Apollonii Pergaei Locorum Planorum*, lib. ii., *Restituti à R. Simson*, (Glasguæ, 1749.)

LOCUSTS. See ACRIDOPHAGI, and ENTOMOLOGY.

LODI is a town of Italy, situated on an eminence in a plain, watered by the river Adda. It is well built, and encircled with walls, and contains a cathedral, two collegiate and seven parish churches, and 26 convents. It carries on a trade in cheese and smoaked tongues; and there is in the town a manufacture of earthenware resembling china. Population about 12,000. An account of the battle of Lodi will be found under the article FRANCE, vol. ix. p. 637.

LOEFLING. See BOTANY.

LOESCHMAN'S IMPROVED SCALE, and Instruments of Music. Some time previous to the year 1809, Mr. David Loeschman, piano-forte maker, of Newman Street, London, set about contriving more convenient modes of carrying into effect the improvements in piano-fortes, as to extending their scale, which the late Dr. Robert Smith, of Cambridge, had attempted, and partially accomplished on his harpsichord, some years prior to 1758; and he has described them in the 2d edition of his *Harmonics*, and in a pamphlet soon after published, as a postscript to it. Mr. Loeschman having succeeded in his attempts, he took out a patent, dated 26th July 1809, for his improvements on piano-fortes and organs, which made them capable of a scale of 24 sounds in each octave, without requiring any additional finger keys to the 12 in each octave before in use, and without requiring the use of the hand for moving any of the stops during performance, as Dr. Smith's instruments for 21 sounds did; these latter changes being now effected by means of pedals or levers, to be pressed by the feet whenever changes of sound become necessary during the performance or otherwise.

In the *Philosophical Magazine*, vol. xxxvii. p. 326, and vol. xxxviii. p. 47, Mr. Loeschman's specification of his invention is inserted, to which we must beg to refer; and in vol. xxxix. p. 418, of the same work, are inserted the elements of the scale of 24 notes on Mr. Loeschman's instruments, to whatever system they may be tuned, they being adapted to any of the various ones which have been proposed by writers. Mr. Loeschman himself prefers the *mean tone*, or perfect IIIrd system, to all others, even on his piano-fortes. See our article MEAN TONE *System*. (*ω*)

LOG. See NAVIGATION.

LOGARITHMS.

LOGARITHMS are a class of numbers deduced from the series of natural numbers, 1, 2, 3, 4, &c. (continued indefinitely,) and so related to them, that if there be formed any series of numbers continued in geometrical progression, their corresponding logarithms will be a continued arithmetical progression. It is from this property of logarithms that they are of such great utility in calculation; because, when the logarithms of all numbers to any extent are known, and arranged opposite to them in a table, any product will be found opposite to the logarithm, which is the sum of the logarithms of its factors, and any quotient opposite to the logarithm, which is the difference of the logarithms of the divisor and dividend: Hence the products and quotients of the natural numbers may be found by the addition and subtraction of their logarithms, as will be more fully explained in the course of this article.

SECTION I.

HISTORY OF LOGARITHMS.

THE invention of logarithms, like many others, has been the offspring of necessity. In the infancy of astronomy, before the use of accurate instruments, and the discovery of the refined mathematical theories to which they have led, the calculations were fewer and shorter than in modern times. As the science advanced, however, they became more laborious and irksome, so as to render some method of abridging them highly desirable.

About the end of the 16th century, some ingenious contrivances were found, by which the labour of calculation might in particular cases be shortened. But the most effectual, and indeed the only adequate remedy, was the artifice of logarithms, which, from its great utility, has formed an epoch in the history of science.

This admirable invention is, beyond all question, due to John Napier, (or Neper,) Baron of Merchiston, in Scotland, who gave it to the world in a book written in Latin, and entitled *Mirifici Logarithmorum Canonis descriptio, ejusque usus in utraque Trigonometria, ut etiam in omni Logistica Mathematica, Amplissimi, Facillimi, et expeditissimi explicatio. Auctore ac inventore Joanne Nepero Barone Merchistonii.* The work was printed at Edinburgh in the year 1614*; and it was dedicated to Charles, Prince of Wales, afterwards Charles I. The preface is worthy of notice, inasmuch as it exhibits the motive which led to this valuable discovery. "Seeing," says author, "there is nothing (right well-beloved students in the mathematics) that is so troublesome to mathematical practice, nor that doth more molest and hinder calculators, than the multiplications, divisions, square and cubical extractions of great numbers, which, besides the tedious expense of time, are, for the most part, liable to many slippery errors: I began, therefore, to consider in my mind by what certain and ready art I might remove these hindrances; and having thought upon many things to this purpose, I found at length some excellent brief rules, to be treated of (perhaps) hereafter. But amongst all, none more profitable than this, which, together with the hard and tedious multiplications, divisions, and extractions of roots, doth also cast away from the work itself, even the very numbers themselves that are to be multiplied, divided, and resolved into roots, and putteth other numbers in their place, which perform as much as they can do, only by addition and subtraction, division by two, and division by three; which secret invention, being (as all other good things are) so much the better, as it shall be the more common, I have thought proper to set forth for the public use of all mathematicians. Therefore, learned mathematicians, enjoy it freely, and receive it with as much good will as I have given it. Farewell."

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* This curious book has of late years been reprinted, with great care, by Mr. Baron Maseres, in his *Scriptores Logarithmici*, vol. 6.

The work itself is divided into two books. The first contains, in the two first chapters, a definition of logarithms, and a geometrical method of conceiving them to be generated by the motion of a point along a straight line. The third chapter contains a description of the inventor's table of logarithms; and the fourth and fifth shew how to find the number to any given logarithm, and, reversely, the logarithm to any given number; also how to find any term of three or four continued proportionals. The second book teaches the application of logarithms to plane and spherical trigonometry, with examples of the solutions of the various cases. The remainder of the work is the Table, which gives the natural sines and their logarithms to every minute of the quadrant, with subsidiary columns, by which the logarithmic tangents and secants may be found. From this table the logarithm of a number is found, by first seeking in any table the arc whose natural sine, or tangent, or secant, is the number, and then the logarithm corresponding to such sine, &c. in his Table.

Napier did not explain in his first work the way in which he had calculated his Table, but he promised to publish it afterwards, if his invention received the approbation of the learned. Almost immediately after the publication of Napier's book, it was translated into English by Edward Wright, an ingenious mathematician of that period, and the inventor of what is improperly called Mercator's chart, a most important improvement in navigation. The translation was sent to Napier at Edinburgh, who perused it carefully, and returned it with his approbation, and the addition of a few lines, which were not in the original work. Wright, however, died soon after; and his son published the translation in the year 1616, with a dedication to the East India Company, and a preface by Henry Briggs—a man to whom the world, in the highest degree, is indebted for his improvements in logarithms, as we shall presently have occasion to explain.

From the particular view which Napier took of the theory, he was led to assume 0 as sthe logarithm of the sine of 90°, or radius, which he expressed by the whole number 10000000, and 23025851 as the logarithm of $\frac{1}{10}$ of the radius, which is the sine of 5° 44′ 21″; hence the logarithms of the series of arcs, increasing from 0° to 90°, formed a decreasing series of positive numbers, the logarithmic tangents in the first half of the quadrant were positive, and in the second half negative; and the logarithmic secants throughout the whole quadrant were negative.

According to Napier's table, although two numbers were expressed by the same figures, for example 1.087 and 10.87, yet their logarithms were altogether dissimilar, the former being—834216, and the latter—23860067. This want of resemblance between the logarithms of numbers expressed by the same characters was a great inconvenience. But Mr. Henry Briggs, professor of geometry at Gresham College in London, in his lectures, proposed to diminish all Napier's logarithms in the proportion of 23025851 to 10000000. By this change, the logarithms of 10, 100, and 1000, would be 10000000, —20000000, and —30000000, respectively; and, in general, the logarithms of all numbers within certain limits, expressed by the same numeral characters, would agree in all their figures, except the first, so that they might be formed from each other by simply changing the first figure.

This, it must be acknowledged, was not a very difficult step in the progress of improvement; indeed, it might have been made by a person far below Briggs in respect of original genius; yet it was attended with great advantage. Briggs communicated his projected improvement to Napier by letter about the spring of the year 1614; and afterwards in the summer of the same year, when he had gone to Scotland to visit him, he again proposed it. Napier greatly approved of it, and wished that it might be adopted, and even said that he himself had thought of making this change before Briggs mentioned it to him; but as he had not thought of it till he had completed the computation of the Table on the first plan, he considered it better to give his invention to the world in its first form, than to delay the publication until he had made the proposed reduction. He said farther, that if his invention should meet with the approbation of mathematicians, and he should be blessed with sufficient health and leisure, he hoped in time to give a second edition of his work, with the improved logarithms.

This first improvement in logarithms seems to have belonged pretty much alike to Napier and Briggs: Indeed it was first mentioned publicly by the latter; but in all probability Napier had thought of it, as he stated, before he knew what Briggs had done.

Napier communicated to Briggs another improvement which he proposed to make in logarithms; this was, to make 0 the logarithm of the ten millionth part of the radius, instead of making it the logarithm of the radius itself. By this change, the inconvenience of having all the secants and half the tangents negative, while the other half and the sines were positive, was taken away; for then the sines and tangents that exceeded the ten millionth part of the radius, and all the secants, were rendered positive, and thus no attention was necessary in regard to the sines. This change, combined with the former, gave 10000000 for the logarithm of 10, and 20000000 for the logarithm of 100, and 30000000 for the logarithm of 1000, and so on, still expressing the logarithms entirely by whole numbers. These were the only two improvements made in logarithms during Napier's lifetime, either by himself or by Briggs. He died in the year 1618, in his 68th year.

After the death of Napier, Briggs, who continued during his whole life to cultivate this useful invention with the greatest success, made a third improvement, which consisted in reducing the logarithms of the several powers of 10, viz. of 10^1, 10^2, 10^3, 10^4, &c. from the high numbers 10000000, 20000000, 30000000, 40000000, &c. to the small numbers 1, 2, 3, 4, &c. which are the mere indices of those powers. By this, the logarithms of numbers between 1 and 10, between 10 and 100, &c. were expressed by mixed numbers, the integer part of which was the logarithm of the next lower power of ten. Thus the logarithm of $12 = 10 \times 1.2$ was 1.0791812, that of $120 = 10^2 \times 1.2$ was 2.0791812, &c. This is the system of logarithms in general use at the present day; and which are with great propriety called *Briggs' Logarithms*.

It has been remarked, that although Briggs was the earliest that proposed any change in the table of logarithms, first publicly in his lectures, and afterwards in conversation with Napier; yet this celebrated man never took the least notice of any claim that Briggs might have as an improver of his valuable invention, although it appears that Briggs expected he would have done him this justice; for in the preface to his *Logarithmorum Chilias prima*, he says, "Why these logarithms differ from those set forth by their illustrious inventor, of ever-respectful memory, in his *Canon Mirificus*, it is to be hoped his posthumous work will shortly make appear." However, as Napier, in his *Rabdologia*, published in the last year of his life, had not noticed Briggs' improvement, but merely spoke of his own alteration in his logarithms, and said, "that he designed to publish their construction and use, but left the calculation to his dear friend, Mr Briggs;" and, farther, as no mention was made of his claim in the *Mirifici Logarithmorum Canonis constructio*, published by Napier's son after his father's death, Briggs thought it proper to assert his claims, and to state publicly what had passed between him and Napier (as we have already stated,) on the subject, in the preface to his *Arithmetica Logarithmica*. Hence, it has been inferred, that as Napier had been the inventor, he also wished to be supposed the sole improver of his own invention. We have, however, Napier's own assertion, that he had thought of the alteration himself before Briggs had communicated his ideas on the subject: and it may be easily believed, that the mind which could at first conceive so admirable an idea, might have gone one step farther, and have made the notable improvement that Briggs had certainly added to the invention.

There was another person who contributed to the improvement of logarithms, namely, John Speidell, a learned and ingenious mathematician, who taught mathematics in London, from about the year 1607, to some time after the year 1646. He, in 1619, (the year immediately following that in which Napier died,) published a table of *new logarithms*, different from that of Napier, but derived from them, by subtracting each from the whole number 10000000, which is greater than the greatest logarithm in Napier's table, viz. 40317433, or the logarithm of the sine of one minute of a degree. These new logarithms obviated the inconvenience of having two classes, viz. positive and negative, as in Napier's table; for in Speidell's table they were all positive. Another inconvenience in Napier's table arose from its exhibiting only the logarithms of such numbers as were the sines, tangents, and secants of arcs, differing from each other by one minute throughout the quadrant, the radius being supposed 10000000, so that the logarithms of the intermediate numbers were derived from these, by making proportions. To remedy this, Speidell gave, in the sixth edition of his work, a table of Napier's logarithms for the integer numbers, 1, 2, 3, 4, 5, &c. to 1000, together with their differences and arithmetical complements; as also the halves of the said logarithms, with their differences and arithmetical complements, which halves were consequently the logarithms of the square roots of the numbers. But instead of making the logarithms decrease as the numbers increased, as Napier had done, he made the logarithms and numbers increase together, so that 0 being the logarithm of 1, that of 10, was +2302585, of 100 twice as much, or +4605170, and so on. Speidell's table, in short, was what is now called a table of *Hyperbolic Logarithms*, because they exhibit the areas of certain spaces in an equilateral hyperbola.

In the year 1619, Robert Napier, son of the inventor of logarithms, published, a new edition of his father's book, and also his method of constructing the canon. The title was, *Mirifici Logarithmorum Canonis Descriptio Ejusque usus in Utraque Trigonometria, et etiam in Omni Logistica Mathematica, amplissimi, facillimi et expeditissimi explicatio. Accesserunt opera posthuma. Primo, Mirifici ipsius Canonis constructio, et Logarithmorum ad naturales ipsorum numeros habitudines. Secundo, Appendix de alia, eâque præstantiore Logarithmorum specie construenda. Tertio, Propositiones quædam eminentissimæ, ad Triangula Sphærica mirâ facilitate resolvenda. Auctore ac Inventore Joanne Nepero, Barone Merchistonii, &c.* Scoto. Edin. 1619.

Bartholomew Vincent, a bookseller at Lyons in France, printed there an exact copy of these two works in one volume, in the year 1620. This was the first time they were introduced into France. They had been published at Cologne in Germany about 1618, or 1619, by Benjamin Ursinus, mathematician to the Elector of Brandenburg, in his *Cursus Mathematicus*; and they were again published in 1624, in his *Trigonometria*, with a table of natural sines, and their logarithms, of the Napierian kind, and form to every ten seconds in the quadrant.

The discoveries relating to logarithms were again disseminated in France by Edmund Wingate, who published at Paris, in 1624, two small tracts in the French language; and afterwards at London, in 1626, an English edition of the same, with improvements. Briggs had prepared his *Chilias Prima* in the lifetime of Napier, although it did not come out until 1618, which was after his death. This contained logarithms of his own kind, the earliest that were published, of the first thousand numbers, each carried to eight places of figures. These again were republished by Edmund Gunter, about the year 1620, in his *Canon Triangulorum*, which was a table of artificial or logarithmic sines of Briggs' kind, to every minute of the quadrant to seven places, besides the index, the logarithmic radius being 1.000, &c. This was the earliest table of logarithmic sines and tangents of Briggs' kind that was published. The same ingenious mathematician contrived logarithmic scales for resolving any proportion, and all questions in trigonometry, by the help of a pair of compasses. These are in general use at this day, and are colled *Gunter's Scale*. He introduced Arithmetical complements into the logarithmic arithmetic, and he is said to have been the first to suggest the *logarithmic curve*, so called, because the segments of the axis are the logarithms of the corresponding ordinates. The logarithmic lines were afterwards drawn in various ways by Wingate in 1627, on two separate rulers, sliding against each other; and, in the same year, by Aughtreed, on two concentric circles. The present sliding rule was invented, in 1657, by the noted astrologer Seth Partridge.

Briggs, in 1624, produced his *Arithmetica Logarithmica*, a stupendous work, considering the short time in which it was prepared. It contained the logarithms of 30000 natural numbers, viz. from 1 to 20000, and from 90000 to 100000, to fourteen places of figures besides the index, together with the differences of the logarithms. In the preface, he stated the alteration made in the scale by Napier and himself, as has been already related; he earnestly solicited assistance from others in the computation of the 70000 intermediate logarithms; and he gave an ample treatise on the construction and use of logarithms. Soon after, Adrian Vlacq (or Flack) of Gouda, in Holland, computed the intermediate seventy chiliads: and, in 1627 and 1628, published at that place the *Arithmetica Logarithmica*, which now contained the logarithms of all numbers to 100000, but only to ten decimal places; and to these was added a table of artificial (or logarithmic) sines, tangents, and secants, to every minute of the quadrant.

Briggs himself lived to complete a table of logarithmic sines and tangents for the hundredth part of every degree to fourteen places of figures, besides the index, together with a table of natural sines for the same parts, to fifteen figures, and the tangents and secants for the same to ten places, with the construction of the whole. These were printed at Gouda, under the care of Adrian Vlacq, and mostly completed before 1631, though not published until 1633. But his death, which then happened, prevented him from explaining their use. However, when dying, he entrusted the execution of this duty to his friend Henry Gellibrand, who added a preface, and the application of logarithms to plane and spherical trigonometry; and the whole work came out with the title *Trigonometria Britannica*.

The bookseller, Vlacq, who had superintended the printing of Briggs' work, brought out the same year his own *Trigonometria Artificialis*. This contained the logarithmic sines and tangents to ten places of figures, with their differences to every ten seconds in the quadrant. To them is added Briggs' table of the first 20000 logarithms to the same number of figures, with their differences. The whole was preceded by a description of the tables, and their application. Mathematical science was considerably indebted to the industry and zeal with which Vlacq extended and multiplied logarithmic tables. However, Gellibrand complained of his pirating the *Arithmetica Logarithmica* of Briggs, by which the sale of the original work was injured, and many emendations intended in a second edition were hindered.

While the English mathematicians were so industriously engaged in the cultivation of logarithms, the invention was not neglected on the continent. The aid that it brought to the astronomer rendered it to him infinitely valuable. In shortening his labour, it gave him time for the prosecution of new discoveries, and, in fact, produced the same effect as if the duration of his existence had been lengthened. No wonder, then, that the celebrated Kepler, whose patience in laborious calculation was only equalled by his sagacity in thence educing truth, should have early directed his attention to this interesting subject. He applied his profound mathematical genius to the cultivation of the theory, as soon as Napier's invention was known abroad; and, in 1624, published at Marpurg his *Chilias Logarithmorum ad totidem numeros rotundos, præmissa demonstratione legitima ortus logarithmorum eorumque usus, &c.* And in the following year came out, *Supplementum Chiliadis Logarithmorum, continens præcepta de eorum usu.* The logarithms were of Napier's kind, but to numbers different from his; for Napier's table gives the logarithms of the sines of a series of arcs, increasing by the equal difference of 1 minute; but Kepler's table gives the logarithms of a thousand sines that increase by equal differences; and corresponding to these, the approximate arcs are put down, which of course do not form an arithmetical progression.

Kepler was assisted in the construction of his tables by his son-in-law, Bartschius, who himself gave, in 1629, new tables of logarithms, adapted, as Kepler's were, to astronomical calculation. Kepler was led to treat of logarithms at considerable length, in consequence of the scruples of several of the professors of mathematics in Upper Germany, particularly such as were somewhat advanced in years. They doubted the justness of Napier's demonstration of properties of logarithms, and whether the application of them to trigonometery might not lead to erroneous results; and, at any rate, they reckoned Napier's demonstration illegitimate and unsatisfactory. Kepler's reasoning, which is strictly geometrical, must have satisfied the most scrupulous, and put the utility of logarithms in a very clear and satisfactory light.

Peter Cruger, a Danish astronomer, also published, in 1634, tables of logarithms. These were according to Napier's first plan, and on that account were soon superseded by the tables framed according to the more convenient system of Briggs.

In Italy, Cavalieri appears to have been the earliest that cultivated logarithms. He gave in his *Directorium Universale Uranometricum*, published at Bologna in 1632, tables of sines, tangents, secants, and versed sines, with their logarithms, to eight figures, to every second in the first and last five minutes of the quadrant, to every 5 seconds in the next five minutes, to every 10 seconds in the following ten minutes, to every 20 seconds from twenty to thirty minutes, and to every 30 seconds from thence to 1° 30′; and lastly, to every minute in the remainder of the quadrant. He also gave the logarithm of every number as far as 10000, all according to Briggs' improved form; so that this book, at the time it appeared, must have been a very complete work, and quite a treasure to an astronomer.

In leaving the earlier period of the history of logarithms, it may be proper to notice, that the merit of the first discovery was claimed about the year 1630, by Benjamin Bramer, a German mathematician, for his relation Juste Byrges, who is represented by Kepler in his Rudolphine Tables, as a man of great genius, but extremely modest and indifferent about his inventions. It certainly appears that Byrges published at Old Prague, in the year 1620, a work in German, which, in the title-page, was called *Tables of Arithmetical and Geometrical Progressions, with their explanation, and directions how they might be employed in all sorts of calculations.* Kœstner, the German mathematician, accidentally met with a copy of this work. The tables were on seven sheets and a half, in folio; but their explanation, and the directions for their use were wanting; and this has given reason to conjecture that the work was never entirely finished. They had not the same form as ours, in which the natural numbers 1, 2, 3, &c. proceed regularly with their logarithms opposite to them. In Byrges' tables, the logarithms were arranged in an arithmetical progression, increasing by 10, and were printed in red, with the corresponding natural numbers opposite, expressed by nine figures, and printed in black. There were in all about 33000 logarithms, of lord Napier's kind, with the corresponding numbers proceeding from 0, the logarithm of 100000000 to 230270022, the logarithm of 999999999 or 1000000000; there must have been some mistake in the calculation of the last logarithm, for it ought to have been 230258509. Benjamin Bramer asserted, in 1630, that his relation Byrges had constructed his table more than 20 years before that period; but there is no proof that this was really the case. The table was printed six years after the publication of Napier's *Canon;* and as it cannot be supposed but that Napier completed his invention a considerable time before he published it, his claims to the honour of the original invention may be considered as perfectly entire.

The first computers of logarithms had a prodigious labour to perform, in comparison to what would have been necessary in the present improved state of analytical science. They at first found the logarithms of the prime numbers by the simple operation of interpolating geometrical means between given numbers; and in this way, no fewer than twenty-six interpolations, each requiring a multiplication of eight or ten figures by as many, and an extraction of the square root, were wanted for finding the logarithm of the number 2 to seven or eight figures. Briggs, by various contrivances, and particularly by the invention of his *Differential Method*, greatly shortened the process. Gregory of St. Vincent observed, in his *Quadratura Circuli et Sectionum Coni* (1647), that if one asymptote of a hyperbola be divided into parts in geometrical progression, and from the points of division ordinates be drawn parallel to the other asymptote, these will divide the space between the asymptote and the curve into equal portions: hence it was shown by Mersennus, that by taking the continual sum of these parts, there would be obtained areas in arithmetical progression, and which, therefore, were analogous to a system of logarithms. Thus the theory of logarithms, which had at first been regarded as belonging to Arithmetic, was now connected with the sister science, Geometry; and the calculation of these useful numbers was identified with the quadrature of the hyperbola.

In 1668, Mercator published his *Logarithmotechnia*, a work of great merit, in which he treated of logarithms upon principles purely arithmetical, employing the doctrine of ratios, as had been before done by Kepler. He also showed how to compute them from the hyperbolic areas, which he expressed by an infinite series. This was the first time an infinite series for the rectification of the hyperbola, and consequently for the calculation of logarithms, had been published; but Newton had before that period invented his method of fluxions, which applied to the quadrature of all curves whatever.

James Gregory published his *Exercitationes Geometricæ* in the same year, immediately after the *Logarithmotechnia*, in which he demonstrated geometrically Mercator's quadrature of the hyperbola; also, for the first time, he proved the truth of a very curious property of logarithms, which had at first been discovered by chance: namely, that the enlarged meridian in what is called Mercator's chart is analogous to a scale of logarithmic tangents of half the complements of the latitudes. In this work he gave a series for the quadrature of the hyperbola, or the calculation of logarithms, of the same nature as that found by Mercator.

Lord Viscount Brouncker and Dr. Wallis likewise gave series for the quadrature of the hyperbola and computation of logarithms; but the discoveries of Newton soon made all these easy deductions from a general theory of quadratures.

Dr. Halley, who had a most correct taste in mathematics, considered, with reason, that it was contrary to good method to mix the theory of logarithms, a subject purely arithmetical, with the doctrines of geometry. He accordingly, leaving entirely out of view their analogy to hyperbolic areas, by means of the binomial theorem, investigated the various series by a process purely algebraic. His memoir, entitled, *A most compendious and facile method of constructing the logarithms, exemplified and demonstrated from the nature of numbers, without any regard to the hyperbola, &c.* was given in the *Phil. Trans.* for 1695. In the conclusion, he expresses a hope that he had fulfilled the promise held forth in the title of his memoir; and further, that he had done this without having had recourse to the method of indivisibles, or to the arithmetic of infinites. He has certainly treated the subject in a manner purely arithmetical; but it cannot be said that he has kept altogether clear of the doctrine of infinities.

At this period the theory of logarithms was sufficiently developed, and every difficulty removed: in fact, the facile methods of constructing them came too late to be of any considerable use in the computation of the tables; and at the present day, new methods of constructing them are only interesting as improvements in analysis. We may, therefore, here close their history with an enumeration of the principal works which treat of their theory; and the best and most useful tables.

On the theory, the reader may consult

Napier. *Mirifici Logarithmorum Canonis*, Edin. 1614.

——— *Mirifici ipsius Canonis Constructio, &c. (in Op. Post.)* Edin. 1619.

Briggs. *Lucubrationes et Annotationes in Op. Post. J Neperi.*

——— *Arithmetica Logarithmica*, Lond. 1624.

——— *Trigonometria Britannica*, Goudæ, 1633.

Kepler. *Chilias Logarithmorum ad totidem Numeros rotundos præmissa Demonstratione Legitimâ ortûs Logarithmorum eorumque usus, &c.* Marpurgi, 1624.

——— *Supplementum Chiliadis*, 1625.

Wingate. *Arithmetique Logarithmetique, &c.* Paris, 1624.

——— *The Construction and Use of Logarithms*, Lond. 1626

James Gregory. *Vera Circuli et Hyperbolæ Quadratura*, Padua, 1667.

——— ——— *Exercitationes Geometricæ*, 1668.

James Gregory. *Methodus Componendi Tangentium et Secantium Artificialum, &c.* (published in *Commercium Epistolicum Dom. Johannis Collins, &c.* 1712)

Mercator. *Logarithmo-technia, sive Methodus Construendi Logarithmos, Nova, Accurata, et Facilis*, Lond. 1668.

Mercator. *Illustratio Logarithmo-technia*, *Phil. Trans.* Lond. 1668.

Brouncker. *The Squaring of the Hyperbola by an infinite series*, *&c. Phil. Trans. Lond* vol. iii. 1668.

Wallis. *Letter to R. Noris concerning the Collection of Secants*, *Phil. Trans.* 1668

Barrow. *Lectiones Geometricæ*, (Lect. xii. Ap. 1.) 1674.

Euclid Speidell. *Logarithmo-technia*, *&c.* 1688.

Halley. *A most compendious and facile Method for constructing the Logarithms, exemplified from the nature of Numbers, without any regard to the Hyperbola*, *&c. Phil. Trans.* 1695.

——— *An easy Demonstration of the Logarithmic Tangents to the Meridian Line*, *&c. Phil. Trans.* 1695-6.

W. Jones. *Synopsis Palmariorum Matheseos*, 1706.

——— *On Logarithms*, *in Phil Trans.* vol lxi.

Craig. *Logarithmo-technia Generalis*, *Phil. Trans.* 1710

Sir I. Newton. *Extracts from Letters to Mr. Henry Oldenburgh*, *&c. containing matters relating to Logarithms* (*Commercium Epist Dom. J. Collins*)

——— *The Method of Fluxions*, *&c.* Lond. 1736.

Cotes. *Logometria*, *in Phil. Trans.* 1714, *and Harmonia Mensurarum*, 1722.

Long. *On the Computation of Logarithms*, *in Phil. Trans.* No. 339, 1714.

Dr. Brooke Taylor. *On the Construction of Logarithms*, *in Phil Trans.* No. 352.

Keill. *In a Treatise on Trigonometry*, *given at the end of an edition of Commandin's Euclid.* 1715

Abraham Sharp. *Easy and Compendious Methods of making Logarithms*, *given in Sherwin's Tables*, 3d edit. 1741.

Dodson. *On Infinite Series and Logarithms*, *Phil. Trans.* 1753.

Maseres. *A Dissertation on the Nature and Use of Logarithms*, (*in Elements of Plane Trigonometry*,) 1760.

——— *Scriptores Logarithmici*, 6 vols. 4to. 1791-6, 1801-4-7.

Euler. *Introductio in Analysin Infinitorum*, lib. i. cap. 6.

R. Simson. *Tractatus de Logarithmis*, (*Opera Posthuma*) 1776.

Waring. *Problems concerning Interpolations*, *Phil. Trans.* 1779.

Hellins. *Various Papers relating to Logarithms*, *in Phil. Trans*, 1780–1796.

Lagrange. *Theorie des Fonctions Analytiques*, chap. iv.

Laplace. *Sur la Reduction des Fonction en Tables*, (*in Memoire sur divers points d'Analyse*, *Journal l'Ecole Polytechnique*, t. viii.) 1809.

Manning. *On the Construction of Logarithms*, *Phil. Trans.*

Wallace. *On the Quadrature of the Conic Sections*, *Edin. Phil. Trans.* vol. vi.

Lavernède. *Annales des Mathematiques*, Nos. 1. & 2. Nismes.

Many of these works, highly valuable by their intrinsic merit, and the indications they give of the progress of mathematical science, had become difficult to be obtained. This circumstance led Dr. Hutton, now Emeritus Professor of Mathematics in the Royal Military Academy of Woolwich, to give a pretty full account of some of the more interesting, in the very learned Introduction to his Mathematical Tables, published in 1785. The unwearied industry, the great extent of reading, and the uncommon mathematical skill and judgment shewn by the Doctor in this Introduction, excited the admiration of Francis Maseres, Esq. F. R. S. Cursitor Baron of the Exchequer, who, with a munificence that has seldom been equalled by a private individual, resolved to reprint and collect into one work such as were rare and most deserving of preservation. This he has accordingly done in his *Scriptores Logarithmici* of which two volumes came out in 1791, and four more at different times since that period.

The early tables of logarithms, interesting chiefly in relation to the history of the invention, have already been enumerated. Those of Briggs and Vlacq will always be esteemed on account of their extent, but they can seldom be procured. It is a remarkable fact, that, while, in Europe, the tables of Vlacq, the most complete of their kind, had become very scarce, and no one would run the risk of bringing out a new edition, they were reprinted in the royal palace of the Emperor of China, with Chinese characters. The title, rendered into Latin, was *Magnus Canon Logarithmorum, tum pro sinibus ac tangentibus ad singula dena secunda, tum pro numeris absolutis ab unitate ad* 100000. *Typis sinensibus in aula Pekinensi jussu imperatoris* (*Kanghi*) *excusus*, 1721. The work extended to three volumes folio, and was printed on Chinese paper.

The more useful tables, whether from their extent or commodiousness, will be found in the following list.

Briggs. *Arithmetica Logarithmica*, 1624.

——— *Trigonometria Britannica*, 1633.

Vlacq. *Arithmetica Logarithmica*, 1628.

——— *Trigonometria Artificialis*, 1633.

Nathaniel Roe. *Tabulæ Logarithmicæ*, Lond. 1633. These tables contain Briggs' logarithms from 1 to 100000 to eight places, and the logarithmic sines and tangents to every 100th part of each degree to ten places.

John Newton. *Trigonometria Britannica*, 1658. This work contains logarithms of numbers from 1 to 100000, and logarithmic sines and tangents to 1000th parts in the first three degrees, and to 100th parts in the remainder. The logarithms of numbers were in this work, for the first time, arranged in the convenient form now generally adopted.

Sherwin. *Mathematical Tables*, in 8vo. 1706. The best edition (revised by Gardiner) is that of 1742. This work contains the logarithms of 101000 numbers, and the logarithmic sines, tangents, secants, and versed sines, for every minute of the quadrant to seven figures.

Gardiner. *Tables of Logarithms for all numbers from* 1 *to* 102100, *and for the sines and tangents of every ten seconds of the quadrant, as also for the sines of the first* 72 *minutes to every single second*, *&c.* 4to. 1742. This work is in the highest repute for accuracy and usefulness.

Dodson. *The Antilogarithmic Canon, being a Table of Numbers, consisting of eleven places of figures corresponding to all logarithms under* 100000 ; *whereby the logarithm for any number, or the number for any logarithm, each under twelve places of figures, are readily found.* London, 1742.

Shultze and Vega have each published valuable tables of logarithms in Germany, the former at Berlin (1778), and the latter at Vienna (1783), both in 8vo.

Vega has also published *Thesaurus Logarithmorum* *completus ex Arithmetica Logarithmica et ex Trigonometria Artificiali Adriani Vlacci Collectus, &c.* Lips. 1795, in folio.

Callet. *Tables portatives de Logarithmes, &c.* 1783. This is a republication of Gardiner's tables. A stereotype edition of this work was printed by Didot in 1795. It contains the logarithms of numbers from 1 to 108000, the logarithmic sines and tangents for every second in the first five degrees, and for every ten seconds in all the other degrees of the quadrant; and, according to the new division of the quadrant, (see Trigonometry,) for every ten millionth parts of the quadrant, &c. It contains also many subsidiary logarithmic tables of great utility in calculation.

Hutton. *Mathematical Tables, containing Common Hyperbolic, and Logistic Logarithms; also Sines, Tangents, Secants, and Versed Sines, both natural and logarithmic, &c.* 1785. This work is in the highest repute, as well for its accuracy as for the very valuable history of logarithms, and of the trigonometrical tables, which it contains. It has now passed through several editions, and is the work best known of any in this country.

Taylor. *Tables of Logarithmic Sines and Tangents for every second of the quadrant, and a Table of Logarithms of all numbers from* 1 *to* 102000, in 4to. London, 1792. This most valuable work is quite a treasure to the calculator, in the present improved state of astronomical knowledge.

About the beginning of the French revolution, an immense system of logarithmic tables was projected by the celebrated Carnot, and, it would seem, was actually prepared for the press, and the printing begun; but like many other projects, the offspring of that teeming period, it was laid aside. However, we have heard that it has been again revived, and that it will be completed, if not as far as was at first intended, at least to an extent sufficient for all the useful purposes of improved science.

SECTION. II.

Theory and Construction of Logarithms.

The theory of logarithms may be explained in various ways. We shall begin with the most elementary, so as to place it within the reach of readers whose mathematical knowledge does not extend beyond the operations of Arithmetic; and as we shall frequently have occasion to refer to the properties of arithmetical and geometrical series or progressions, we shall state briefly their nature, and a principal property of each, referring for a more full explanation to Algebra, sect. viii.

2. An arithmetical progression is a series of numbers which increase or decrease by equal differences. The series of natural numbers, 1, 2, 3, 4, &c. is of this kind; so is also the series of numbers,

1, 3, 5, 7, 9, 11, &c.

Here the common difference is 2; but it may be any number, whole or fractional. It is a property of this series, that the double of any term is the sum of the two adjoining terms, so that an *arithmetical mean* between two numbers is half their sum.

A geometrical progression is a series of numbers which increase by a common multiplier, or decrease by a common divisor called their *ratio*. The series

1, 2, 4, 8, 16, 32, 64, &c.

is of this kind. Here the ratio is 2, but it may be any number, whole or practical. In a geometrical series the square of any term is the product of the two adjoining terms; and hence a *geometrical mean* between two numbers is the square root of their product.

3. To proceed now with our theory, let us suppose that the terms of any continued geometrical progression which begins with unity, and the terms of any continued arithmetical progression which begins with *zero*, to be written opposite to each other, as in the following table, in which, for the sake of a particular example, the ratio of the geometrical series is 2, and the common difference of the arithmetical is unity.

Geom. Prog.	Arith. Prog
1	0
2	1
4	2
8	3
16	4
32	5
64	6
128	7
256	8
512	9
1024	10
2048	11
4096	12
&c.	&c.

Supposing the two series to be continued to any extent, the numbers of the arithmetical series are called the *logarithms* of the corresponding terms in the geometrical series.

From this definition, it will be easy to verify, by induction, the truth of the two following properties of logarithms.

1. *The sum of the logarithms of any two terms of the geometrical series is the logarithm of that term which is their product.*

2. *The difference of the logarithms of any two terms of the series is the logarithm of that term which is the quotient of the greater divided by the less.*

For example, the sum of 5 and 7, the logarithms of the terms 32 and 128, is 12, the logarithm of the term 4096, which is the product of 32 and 128.

Again, the difference of 10 and 6, the logarithms of the terms 1024 and 64, is 4, the logarithm of the term 16, which is the quotient of 1024 divided by 64.

By these properties, multiplication and division of any terms of the geometrical progression may be readily performed, by the addition and subtraction of their logarithms and the inspection of the table. Thus, to find the product of the terms 16 and 64, we add their logarithms 4 and 6, and opposite to 10, the sum, in the arithmetical series we find 1024, the answer. Again, to divide the term 2048 by the term 256, we subtract 8, the logarithm of the latter, from 11, the logarithm of the former, and opposite to 3, we find 8, the quotient.

4. We may suppose a term to be interpolated between each two adjoining terms of both series, by taking the square root of their product in the geometrical series, and half their sum in the arithmetical series; each would then consist of double the number of terms, the new terms in the geometrical series would be approximate values of the square roots of the numbers $2 = 1 \times 2$,

$3=2\times4$, $32=4\times8$, and so on; and those of the arithmetical series, or the logarithms of the others, would be $.5=\frac{0+1}{2}$, $1.5=\frac{1+2}{2}$, $2.5=\frac{2+3}{2}$, &c. The first seven terms of the two series would then be as follows:

Geom. Series.	Arith. Series.
1.000000	0.0
1.414214	0.5
2.000000	1.0
2.828427	1.5
4.000000	2.0
5.656854	2.5
8.000000	3.0
&c.	&c.

We might go on in this way, interpolating terms continually; every new interpolation would change the ratio and common difference; but still the two series would have the same relative properties as at first.

5. The terms of the geometrical progression which have the series of numbers 1, 2, 3, 4, &c. for their logarithms, proceed, in Briggs' system, in a decuple ratio, thus:

Geom. Series.	Arith. Series, or Log.
1	0
10	1
100	2
1000	3
10000	4
100000	5
&c.	&c.

If we conceive a new term to be interpolated between each adjoining pair in either series, as explained in last article, and this operation to be again repeated on the resulting series, and so on continually, the number of terms in the two series will continually increase, and each succeeding interpolation will produce a new geometrical series, having smaller differences between its terms than those of the preceding series.

If, taking a particular case, we suppose the extreme terms of the geometrical series to be 1 and 100000, as in the preceding short Table, a term interpolated between each adjoining pair would increase the number to 11, a second interpolation would produce 21, and a third 41. Proceeding in this way, after twenty repetitions of the process, there would be produced two corresponding series, each having 5242881 terms, and the last two in the geometrical series would be 99999.78 and 100000, differing only by the small fraction .22: and as the terms go on increasing, no other adjoining two would differ by so much; therefore some one or other would be nearly equal to every whole number from 1 to 100000, and the corresponding terms of the arithmetical series would be the logarithms of the numbers, according to Briggs' system.

6. We shall now show how, according to this mode of conceiving logarithms, they may be actually calculated; and as a particular example, we shall find Briggs' logarithm of 5.

1*mo*. The number 5 is between 1 and 10, the logarithms of which we already know to be 0 and 1: Let a geometrical mean be found between the two former, and an arithmetical mean between the two latter. The geometrical mean will be the square root of the product of the numbers 1 and 10, which is 3.162277, and the arithmetical mean will be half the sum of the logarithms 0 and 1, which is 0.5, therefore the logarithm of 3.162277 is 0.5. But as the mean thus found is not sufficiently near to the proposed number, we must proceed with the operation as follows:

2*do*. The number 5, whose logarithm is sought, is between 3.162277, the mean last found, and 10, the logarithms of which we know to be 0.5 and 1; we must now find a geometrical mean between the two former, and an arithmetical mean between the two latter. The one of these is $\sqrt{(3.162277\times10)}=5.623413$, and the other is $\frac{1+0.5}{2}=0.75$; therefore the logarithm of 5.623413 is 0.75.

3*tio*. We have now obtained two numbers, namely, 3.162277 and 5.623413, one on each side of 5, together with their logarithms 0.5 and 0.75, we therefore proceed exactly as before, and accordingly we find the geometrical mean, or $\sqrt{(3.162277\times5.623413)}$, to be 4.216964, and the arithmetical mean, or $\frac{0.5+0.75}{2}$, to be 0.625; therefore the logarithm of 4.216964 is 0.625.

4*to*. We proceed in the same manner with the numbers 4.216964 and 5.62341, (one of which is less and the other greater than 5,) and their logarithms 0.625 and 0.75, and find a new geometrical mean, viz. 4.869674, and its corresponding arithmetical mean, or logarithm, 0.6875.

We must go on in this way, till we have found twenty-two geometrical means, and as many arithmetical terms, or logarithms. And that we may indicate how these are found from each other, let the numbers 1 and 10 be denoted by A and B, and their geometrical means taken in their order by C, D, E, &c. then the results of the successive operations will be as in the following Table:

	Numbers.	Logarithms.
$A =$	1.000000	0.0000000
$B =$	10.000000	1.0000000
$C = \sqrt{AB} =$	3.162277	0.5000000
$D = \sqrt{BC} =$	5.623413	0.7500000
$E = \sqrt{CD} =$	4.216964	0.6250000
$F = \sqrt{DE} =$	4.869674	0.6875000
$G = \sqrt{DF} =$	5.232991	0.7187500
$H = \sqrt{FG} =$	5.048065	0.7031250
$I = \sqrt{FH} =$	4.958069	0.6953125
$K = \sqrt{HI} =$	5.002865	0.6992187
$L = \sqrt{IK} =$	4.980416	0.6972656
$M = \sqrt{KL} =$	4.991627	0.6982421
$N = \sqrt{KM} =$	4.997240	0.6987304
$O = \sqrt{KN} =$	5.000052	0.6989745
$P = \sqrt{NO} =$	4.998647	0.6988525
$Q = \sqrt{OP} =$	4.999350	0.6989135
$R = \sqrt{OQ} =$	4.999701	0.6989440
$S = \sqrt{OR} =$	4.999876	0.6989592
$T = \sqrt{OS} =$	4.999963	0.6989668
$V = \sqrt{OT} =$	5.000008	0.6989707
$W = \sqrt{TV} =$	4.999984	0.6989687
$X = \sqrt{WV} =$	4.999997	0.6989697
$Y = \sqrt{VX} =$	5.000003	0.6989702
$Z = \sqrt{XY} =$	5.000000	0.6989700

As the last of these means, viz. z, agrees with 5, the proposed number, as far at least as the sixth place of decimals, we may safely consider them as very nearly equal, therefore their logarithms will also be very nearly equal, that is, the logarithm of 5 will be 0.6989700 nearly. And by a like process the logarithm of any other number may be found.

7. From the logarithm of 5, and the logarithm of 10, which in Briggs' system is 1, we may find the logarithm of 2, the quotient of 10 divided by 5; we have only to subtract the logarithm of 5 from the log. of 10, and the remainder 0.3010300 is the log. of 2.

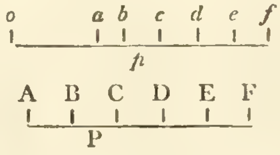
The logarithms of 20, 200, 2000, &c. are got from the logarithms of 2 and 10, 100, 1000, &c. by adding the logarithms of 2 and 10 for the logarithm of 20, those of 2 and 100 for the logarithm of 200, and so on. It is evident that the logarithm of any number, and the logarithm of the product of that number by any power of 10, will be the same in all the figures after the decimal point.

8. If, in addition to the logarithms of the numbers 2 and 5, the logarithms of 3 and 7 were found, each by a series of interpolations, we might then find the logarithms of many more, such as could be produced from them by multiplication, as $4 = 2 \times 2$, $6 = 2 \times 3$, $8 = 2 \times 2 \times 2$, $9 = 3 \times 3$, $12 = 2 \times 2 \times 3$, $14 = 2 \times 7$, $15 = 3 \times 5$, &c.

In fact, the chief labour of constructing a table is the finding of the logarithms of the prime numbers; for these once known, the logarithms of the composite numbers are obtained by addition of the logarithms of their factors.

9. Having given such a view of the theory and the manner of computing logarithms as may be understood by such as know the common principles of arithmetic, we shall now explain briefly their theory, as delivered by the inventor, and the mathematicians of the early part of the 16th century.

Applying Napier's method, not to his original logarithms, but to such as are now in use, we are to suppose that two points p, P generate lines $a\,f$, AF by continued motion, the former moving with a velocity so regulated, that supposing the increments $a\,b$, $b\,c$, $c\,d$, $d\,e$, $e\,f$, &c. to be generated in equal times, and o to be a given point in the line $a\,b$ produced, these may be among themselves as the distances $o\,a$, $o\,b$, $o\,c$, $o\,d$, $o\,e$, &c. while the latter moves with an uniform velocity, and generates the increments AB, BC, CD, DE, &c. which are all equal in the same times. Then because, by hypothesis, $o\,a : o\,b :: a\,b : b\,c$, by alternation, $o\,a : a\,b :: o\,b : b\,c$, and by composition $o\,a : o\,b :: o\,b : o\,c$. In like manner it may be shewn, that $o\,b : o\,c :: o\,c : o\,d$, and again, that $o\,c : o\,d :: o\,d : o\,e$, &c. so that $o\,a$ and $o\,b$, $o\,c$, $o\,d$, $o\,e$, &c. the distance of the moving point p from the origin o, at the end of equal times, constitute a series of continued geometrical proportionals; while AB, AC, AD, AE, &c. the distances gone over by the other point P in the same times, form a corresponding series of continued arithmetical proportionals. The latter series of magnitudes will therefore be the *logarithms* of the former, (Art. 3.) And since, by the continued motion of the point p, its distance from o will successively acquire every degree of magnitude to which there must be a corresponding distance described by the other point P, it follows that a system of logarithms may be adapted to any magnitudes whatever; also, that there may be an endless variety of systems, each depending on the ratio of the velocities with which the moving points leave the positions a and A.



This application of motion to the theory of logarithms was, at the time, a happy thought of the inventor; it certainly gives clear notions of their nature, although it affords no aid in their computation. It is the more remarkable, as the inventor of fluxions, at a later period, also employed the theory of motions in developing its principles. In both cases, however, the application was quite a thing of convenience.

10. The next view which we shall take of the subject originated with Kepler, who, in consideration of the objections of the elderly German mathematicians to Napier's method, founded the theory on the doctrine of ratios.

In order to make the *ratios* of quantities, or the relations that they have to each other in respect of magnitude, a subject of geometrical reasoning, mathematicians regard them as a species of quantities themselves, which, like geometrical magnitudes, admit of being equal and unequal; of several being united so as to form a whole; and, on the other hand, of a whole being resolved into parts. This species of quantity or magnitude, which is quite a creation of the mind, differs from the other objects of geometrical discussion, viz. lines, surfaces, &c. in this, that it is necessary to give definitions of what is meant by equal ratios; also by a ratio greater or less than another ratio, and by the sum or difference of ratios; whereas the like affections and combinations of geometrical magnitudes arise immediately out of their nature, and do not require to be defined.

11. When two quantities A and C are compared by the intervention of a third B, the ratio of A to C is considered as made up, or *compounded*, of the ratios of A to B and of B to C, (Geometry, Sect. V. Def. 10.) According to this definition, to express a ratio which is the sum of the ratios of P to Q, and of R to S, (the terms of each ratio being any quantities of the same kind,) we may take any quantity A, and find B a fourth proportional to P, Q and A; also C a fourth proportional to R, S and B; then, the ratio which is compounded of the ratios of P to Q and R to S, will be the ratio compounded of the ratios of A to B and B to C; that is, the ratio of A to C.

It is of no consequence what may be the magnitude of the assumed quantity A; for if we suppose it to have a different value a, and b, c, to be the corresponding values of B and C; because $A : B :: a : b$, and $B : C :: b : c$, therefore $A : C :: a : c$, (Geometry, Sect. 5. Prop. 8:) thus the consistency of the definition of a ratio which is the sum of two ratios is established.

12. From the definition of a compounded ratio, that of a double or rather *duplicate* ratio naturally follows; also that of a *triplicate* ratio: (Geometry, Sect. V. Def. 11 and 12;) and in general, of a ratio that is any multiple of another ratio. Thus, ratios, like geometrical magnitudes, may be measured by numbers, some quantity of their own kind being regarded as the unit.

Let us suppose that r is any number, and that the ratio of r to 1 is the unit by which all ratios are to be measured; the ratio of r^2 to 1, which is duplicate of the ratio of r to 1, will be measured by 2; the ratio of r^3 to 1, its triplicate, will be measured by 3; and in general, the measure of the ratio r^m to 1, (m being any number whatever,) will be m. In like manner, the measure of the ratio of r^n to 1 will be n, (n being any number,) and the measure of the ratio of r^{m+n} to 1 will be $m+n$: but r^{m+n} is the product of r^m and r^n; hence it follows, that *the measure of the ratio of the product of two numbers to unity, is the sum of the measures of the ratios which the numbers themselves have each to unity.* From this it appears, that the measures of the ratios of numbers to 1, have the very same properties as the logarithms of numbers, (art. 3.) so that the logarithm of a number may be defined *the measure of its ratio to unity.*

13. The number r, (the antecedent of the unit of ratios,) must be supposed a little greater than 1, in order that r^n, some one of its powers, may coincide, or almost coincide, with any number that can be assigned. With this condition, r may be any number whatever; and therefore there may be innumerable different systems of logarithms. If the measure of the ratio of 10 to 1 be assumed equal to 10000000, then $r^{10000000}$ must be equal to 10, and r must be the 10000000th root of 10, which is 1.0000002302585 nearly: If a series of continual proportionals were formed, having one for its first term, and this number r for its second, the 3010300th term of the series would be 2, and the 4771213th term would be 3, &c. and of course the 10000000th term would be 10; therefore 10000000 being assumed as the measure of the ratio of 10 to 1; 3010300, and 4771213, would be the measures of the ratios of 2 to 1, and of 3 to 1 respectively: but as, instead of these numbers, any proportional parts of them may be taken, we may make the ratio of 10 to 1 the unit by which all other ratios are measured, and then its measure being 1, the measure of the ratio of 2 to 1 will be .3010300; that of 3 to 1 will be .4771213, and so on with other numbers.

Regarding then the ratio of r to 1 as an *element*, all other ratios having 1 as a common consequent may be measured each by the number of times it contains that element, according to the notion of the multiple of a ratio laid down in Geometry, (Sect. 3. Def. 11 and 12.) and these numbers, or any others proportional to them, are in fact the logarithms of the numbers which are the antecedents of the ratios. Hence, indeed, they have been called *logarithms;*—which word, if regard is had to its etymology, is λογῶν ἀριθμοὶ, or the number of small and equal ratios, or, as Dr. Halley calls them, *ratiunculæ*, contained in the several ratios of quantities one to another.

14. This mode of treating logarithms as the measures of ratios is quite legitimate, and agreeable to the theory of proportion, as received from the ancient geometers. It is, however, considerably abstract, in as much as the doctrine of ratios on which it rests is the most subtle speculation in geometry as delivered by Euclid. For a more complete developement of this view of the subject, the reader may consult the writings of Kepler already quoted; also, Saunderson's *Algebra*, Maseres' *Trigonometry*, (art. 184.) and the *Posthumous Works* of Dr. R. Simson.

15. There is a view of the subject which readily adapts it to the resources of modern analysis, namely, that in which all numbers are considered as the powers of some assumed number; and then the indices of those powers are the logarithms of the numbers. We have treated of logarithms so fully, under this point of view, in *Algebra*, Sect. xix. as to render it unnecessary to do more in this place, than briefly to recapitulate the conclusions which have there been brought out.

16. It has been found (Algebra, art. 341.) that if $(1+v)$ denote any number

(A)

$$\text{Log.}\ (1+v)=\text{M}\left\{v-\frac{v^2}{2}+\frac{v^3}{3}+\frac{v^4}{4}+\frac{v^5}{5}-,\ \&\text{c.}\right\}$$

Here M denotes a constant quantity, which is the *modulus* of the system, (Algebra, Art. 344.) It is always the reciprocal of the Napierian logarithm of the *radical* number or *basis* of the system. In Napier's System M=1, (Algebra, Art. 343.) but in Briggs' System, (Art. 348.)

$$\text{M}=\frac{1}{2.30258509}=.434294482.$$

Or, more correctly,

$$\text{M}=.4342944819032518276511289189166.$$

This is the series earliest known for the calculation of logarithms. It was first published by Mercator in 1668, but Newton had discovered it in 1666. It gives the logarithm of any number that is but a little greater than 1, with great facility: if v be nearly equal to 1, the series conveys too slowly to be of any use; and if v be greater than 1, it diverges. It may, however, be transformed into others that apply to every possible case. Put $-v$ for $+v$, and we have

$$\text{Log.}\ (1-v)=-\text{M}\left\{v+\frac{v^2}{2}+\frac{v^3}{3}+\frac{v^4}{4}+\frac{v^5}{5}+,\ \&\text{c.}\right\}$$

but $\log.\ (1-v)=-\log.\ \frac{1}{1-v}$, therefore, changing the signs on both sides, we have

(B)

$$\text{Log.}\ \frac{1}{1-v}=\text{M}\left\{v+\frac{v^2}{2}+\frac{v^3}{3}+\frac{v^4}{4}+\frac{v^5}{5}+,\ \&\text{c.}\right\}$$

This is Dr. Wallis's series, and it is always applicable; for whatever number we put $=\frac{1}{1-v}$, v will be a proper fraction.

By adding together the formulæ (A) and (B), and remarking that $\log.\ (1+v)+\log.\ \frac{1}{(1-v)}=\log.\ \frac{1+v}{1-v}$, we have

(C)

$$\text{Log.}\ \frac{1+v}{1-v}=\text{M}\left\{v+\frac{v^3}{3}+\frac{v^5}{5}+\frac{v^7}{7}+,\ \&\text{c.}\right\}$$

which is James Gregory's series for the logarithm of a number.

To give it a more general form, let us put $\frac{1+v}{1-v}=\frac{u}{t}$, then $v=\frac{u-t}{u+t}$ and the formula becomes

(C)

$$\text{Log. } \frac{u}{t} = 2\text{M} \left\{ \frac{u-t}{u+t} + \tfrac{1}{3}\left(\frac{u-t}{u+t}\right)^3 + \tfrac{1}{5}\left(\frac{u-t}{u+t}\right)^5 +, \&c. \right\}$$

Of the three series which we have yet found, this last is the most convenient, and most generally applicable. It converges very fast, when the difference between the numerator and denominator of the fraction $\frac{u}{t}$ is a small whole number: therefore, in computing a table, it would be proper to reduce the calculation of all the logarithms to this case, which may be done by deducing them one from another. Thus, if we put $u = x + 1$, and $t = x$, then $u - t = 1$, $u + t = 2x + 1$, $\frac{u-t}{u+t} = \frac{1}{2x+1}$ and $\log. \frac{u}{t} = \log. u - \log. t = \log. (x + 1) - \log. x$. These quantities being substituted in the last series, give

(D)

$$\log. (x + 1) = \log. x + 2\text{M} \left\{ \frac{1}{2x+1} + \frac{1}{3}\frac{1}{(2x+1)^3} + \frac{1}{5}\frac{1}{(2x+1)^5} + \&c. \right\}$$

Hence, having found the logarithm of any number, we can find the logarithm of the next in order by a series, which, in the most unfavourable case, (that of $x = 1$), converges with great rapidity.

Again, let us assume $u = x^2, t = x^2, -1 = (x-1)(x+1)$, then $u - t = 1$, $u + t = 2x^2 - 1$, $\log. \frac{u}{t} = \log. \frac{x^2}{(x-1)\ (x+1)} = 2 \log. x - \log. (x - 1) - \log. (x + 1)$.

These being thus substituted in the series, give

(E)

$$\log. x = \tfrac{1}{2} \left\{ \log. (x-1) + \log. (x + 1) \right\}$$

$$+ \text{M} \left\{ \frac{1}{2x^2-1} + \frac{1}{3}\frac{1}{(2x^2-1)^3} + \frac{1}{5}\frac{1}{(2x^2-1^5} + \&c. \right.$$

This formula gives the logarithm of any whole number by those of the two adjoining numbers, and a series which always converges with great rapidity. It was first given by Dr. Halley.

17. A foreign mathematician, M. Lavernède, has extended the principle by which a logarithm is deduced from other logarithms and a swiftly converging series, in an elaborate Analytical Memoir (*Annales dès Mathematiques*, vol. i. 1811.) He has investigated rational functions of x which admit of being resolved into factors, and which differ only in their last terms. Our limits will not admit of our pursuing his analysis, which besides does not belong to the theory of logarithms, but we shall give some of his results.

1. The functions,

$$(x-1)^2 (x+2) = x^3 - 3x + 2,$$
$$(x+1)^2 (x-2) = x^3 - 3x - 2,$$

which admit of being resolved into factors, differ in the last term only. Let us assume the first equal to u, and the second equal to t, then

$\log. \frac{u}{t} = 2 \log. (x-1) + \log. (x + 2) - 2 \log. (x + 1) - \log. (x - 2)$.

Let us put $\frac{u-t}{u+t} = \frac{2}{x^3 - 3x} = \text{T}$, and we have from formula (C)

(F)

$$2 \log. (x-1) + \log. (x+2) - 2 \log. (x+1) - \log. (x-2)$$
$$= 2\text{M} \left\{ \text{T} + \tfrac{1}{3}\text{T}^3 + \tfrac{1}{5}\text{T}^5 + \tfrac{1}{7}\text{T}^7 + \&c. \right\}$$

This formula gives the logarithm of $x+2$ from those of $x-2$, $x-1$, and $x+1$. It has been given by Delambre in his introduction to the Tables of Borda.

2. The functions

$$(x + 1)^2 (x + 4) = x^3 + 6x^2 + 9x + 4,$$
$$x (x + 3)^2 = x^3 + 6x^2 + 9x,$$

have the requisite property: by making the former $= u$, and the latter $= t$, also

$$\frac{u-t}{u+t} = \frac{2}{x^3 + 6x^2 + 9x + 2} = \text{T}$$

we get

(G)

$$2 \log. (x + 1) + \log. (x + 4) - \log. x - 2 \log. (x + 3)$$
$$= 2\text{M} \left\{ \text{T} + \tfrac{1}{3}\text{T}^3 + \tfrac{1}{5}\text{T}^5 + \tfrac{1}{7}\text{T}^7 + \&c. \right\}$$

The substance of this formula was given long ago by Muller, in his *Treatise on Conic Sections and Fluxions*. It serves to find the logarithm of a number $x + 4$ from those of x, $x + 1$, and $x + 3$.

3. Passing to functions of the fourth degree, these satisfy the requisite conditions.

$$(x-4)(x+4)(x-3)(x+3) = x^4 - 25x^2 + 144,$$
$$x^2 (x-5)(x+5) = x^4 - 25x^2.$$

Hence, putting the former $= t$, and the latter $= u$; also

$$\frac{u-t}{u+t} = \frac{72}{x^4 - 25x^2 + 72} = \text{T},$$

we have

(H)

$$\log. (x-4) + \log. (x+4) + \log. (x-3) + \log. (x+3) -$$
$$2 \log. x - \log. (x-5) - \log. (x+5.)$$
$$= 2\text{M} \left\{ \text{T} + \frac{1}{3}\text{T}^3 + \frac{1}{5}\text{T}^5 + \frac{1}{7}\text{T}^7 +, \&c. \right\}$$

This formula gives the logarithm of $(x+5)$ from those of six inferior numbers.

4. In like manner, from these functions,

$$t = (x+6)(x+3)(x+2)(x-1) = x^4 + 10x^3 + 25x^2 - 36,$$
$$u = x^2 (x+5)^2 = x^4 + 10x^3 + 25x^2,$$

we obtain

$$\frac{u-t}{u+t} = \frac{18}{x^4 + 10x^3 + 25x^2 - 18} = \text{T},$$

and this other formula,

(I)

$$\log. (x+6) + \log. (x+3) + \log. (x+2) + \log. (x - 1)$$
$$- 2 \log. x - 2 \log. (x+5)$$

$$=2\,\mathrm{M}\,\mathrm{T}\left\{+\ \tfrac{1}{3}\mathrm{T}^3+\tfrac{1}{5}\mathrm{T}^5+\tfrac{1}{7}\mathrm{T}^7+\ \&c.\right\}$$

The formula gives the logarithm of $(x+6)$ from the logarithms of five smaller numbers.

We shall not pursue farther this mode of finding formulæ for the computation of logarithms. The author of the memoir referred to, however, carries it to functions of the fifth and sixth degrees, and also shews how they may be applied.

18. We shall now explain briefly, how the formulæ are to be applied to the actual construction of the table.

We may begin with finding Napier's logarithm of 2 from formula (C.)

Putting $u=2, t=1$, we have $u-t=1, u+t=3$; and since in this case $\mathrm{M}=1$, we obtain

$$\log.\ 2=2\left(\frac{1}{3}+\frac{1}{3.3^2}+\frac{1}{5\ 3^5}+\frac{1}{7.3^7}+\ \&c.\right)$$

The calculation is put down at length in Algebra, Art. 347; from which it appears that, as far as eight decimal places,

Nap. log. 2=.69314718.

Napier's logarithm of 5 may be found from the same formula, but more expeditiously from formula (D); for we have log. 4=2 log. 2=1.38629436; and putting $x=4$, we find $\frac{1}{2x\times1}=\frac{1}{9}$: hence the formula gives

$$\log.\ 5=\log.\ 4+2\left(\frac{1}{9}+\frac{1}{3.9^3}+\frac{1}{5.9^5}+\frac{1}{7.9^7}+,\ \&c.\right)$$

Four terms of the series are sufficient to give its sum true to the eighth decimal, to which adding log. 4, we get

Nap. log. 5=1.60943791.

By adding together the logarithms of 2 and 5, we obtain Nap. log. 10=2.30258509; and by dividing unity by this number, we find

M=.434294482.

If we multiply Napier's logarithms of 2 and 5 by this number, they become Briggs', or common logarithms, viz.

log. 2=.30103000, log. 5=.6989700.

The common log. of 3 may be found from those of 2 and 4, by formula (E). Making $x=3$, we have $\frac{1}{2x-1}=\frac{1}{17}$, and

$$\log.\ 3=\tfrac{1}{2}\left(\log.\ 2+\log.\ 4\right)+\frac{\mathrm{M}}{17}+\frac{\mathrm{M}}{3.17^3}+\frac{\mathrm{M}}{5.17^5}+,\ \&c.$$

The sum of three terms of the series are sufficient to give

log. 3 = .47712125.

By adding the logarithms of 2 and 3, we get

log. 6 = .77815125.

Formula (F), which gives the logarithm of a number $x+2$, by means of the logarithms of three lower numbers, $x+1$, $x-1$, $x-2$, may be employed for finding the logarithm of 7. In this case $x=5$ and $\frac{2}{x^3-3x}=\frac{1}{55}=\frac{1}{5.11}$. From the formula we obtain

$$\log.\ 7=2\log.\ 6+\log.\ 3-2\log.\ 4+\frac{2\mathrm{M}}{5.11}+\frac{2\mathrm{M}}{3.5^3.11^3}+,\ \&c.$$

Here two terms of the series are sufficient to give

log. 7=.84509804.

Three times log. 2 gives log. 8=.90309000, and twice log. 3 gives log. 9=.95424251. The logarithm of 10 is unity. The sum of the logarithms of 2 and 6 is the logarithm of 12. The logarithm of 11 may be found from log. 10 by formula (D), or from the logarithms of 10 and 12 by formula (E). By the former,

$$\log.\ 11=\log.\ 10+2\,\mathrm{M}\left\{\frac{1}{21}+\frac{1}{3.21^3}+\frac{1}{5.21^5}+,\ \&c.\right\}$$

and by the latter,

$$\log.\ 11=\tfrac{1}{2}\left(\log.\ 10+\log.\ 2+\log.\ 6\right)$$
$$+2\,\mathrm{M}\left\{\frac{1}{241}+\frac{1}{3.241^3}+,\ \&c.\right\}$$

In this manner the whole table may be computed, each logarithm being deduced from those before it.

19. If it were proposed to compute the logarithm of a large number independently of any other, for example the logarithm of 7351, the number may be expressed thus:

$$7351=1000\times7\times\frac{73}{70}\times\frac{735}{730}\times\frac{7351}{7350};$$

hence $\log.\ 7351=3+\log.\ 7+\log.\frac{73}{70}+\log.\frac{735}{730}+\log\frac{7351}{7350}$.

Thus the determination of the logarithm of the large number 7351 is reduced to the finding of those of the small number 7, and of the three fractions $\frac{73}{70}$, $\frac{735}{730}$, and $\frac{7351}{7350}$, which may be readily found by formula (C.) Thus, putting $u=73$, and $t=70$, we have

$$\log.\ \frac{73}{70}=2\,\mathrm{M}\left\{\frac{3}{143}+\frac{1}{3}\,\frac{3^3}{143^3}+\frac{1}{5}\,\frac{3^5}{143^5}+,\ \&c.\right\}$$

and similarly for the others.

The logarithms of large numbers may also be found thus: Calling N the number, let its square root be taken, and again the square root of its square root, which will be its fourth root, and so on until a root be found that is but a little greater than unity. Let $1+v$ be the nth root of N found in this manner, (n being some power of 2.) Because $\mathrm{N}^{\frac{1}{n}}=1+v$, by the nature of logarithms $\frac{1}{n}\log.\ \mathrm{N}=\log.\ (1+v)$, and by formula (A) we have

$$\log.\ \mathrm{N}=n\log.\ (1+v)=n\,\mathrm{M}\left\{v-\frac{v^2}{2}+\frac{v^3}{3}-\frac{v^4}{4}+\ \&c.\right\}$$

where the series will converge so much the faster as v is smaller.

20. We have given one application of formula (F) to the computation of a single logarithm from others. (art. 18.) We shall now shew how it may be applied to the computation of several at once, viz. those of 2, 3, 5, 7.

Putting x successively equal to 5, 6, 7, 8, we get

$$2\log.4+\log.7-2\log.6-\log.3=2\,\mathrm{M}\left\{\frac{1}{55}+\frac{1}{3.55^3}+\&c.\right\}$$

$$2\log.5+\log.8-2\log.7-\log.4=2\,\mathrm{M}\left\{\frac{1}{99}+\frac{1}{3.99^3}+\&c\right\}$$

$$2\log.6+\log.9-2\log.8-\log.5=2\,\mathrm{M}\left\{\frac{1}{161}+\frac{1}{3.161^3}+\&c.\right\}$$

$$2\log.7+\log.10-2\log.9-\log.6=2\,\mathrm{M}\left\{\frac{1}{246}+\frac{1}{3.246^3}+\&c.\right\}$$

Hence, by resolving the numbers into their factors, we have

$$2\log.2-3\log.3+\log.7=2\,\mathrm{M}\left\{\frac{1}{55}+\frac{1}{3.55^3}+\&c.\right\}$$

$$\log.2+2\log.5-2\log.7=2\,\mathrm{M}\left\{\frac{1}{99}+\frac{1}{3.99^3}+\&c.\right\}$$

$$-4\log.2+2\log.3-\log.5=2\,\mathrm{M}\left\{\frac{1}{161}+\frac{1}{3.161^3}+\&c.\right\}$$

$$-5\log.3+\log.5+2\log.7=2\,\mathrm{M}\left\{\frac{1}{246}+\frac{1}{3.246^3}+\&c.\right\}$$

Here there are four unknown quantities, viz. the logarithms of 2, 3, 5, 7, and as many equations: hence the unknown quantities may all be determined by elimination, as taught in algebra.

21. The logarithms of all the numbers in the table after the first 1000 may be most expeditiously found from these, by computing their differences: for the differences being known, each logarithm may be derived from that before it, by addition only.

From the logarithms of the first thousand numbers we have the logarithms of

10100, 10200, 10300, 10400, &c.

proceeding by equal intervals of 100 to 10000, by simply adding 2 to the index of the logarithms of 101, 102, 103, &c.

Now let N, N′, N″ be any three of the consecutive numbers between 10000, and 100000, which differ by 100; and n, n', n'' any three consecutive numbers between N and N″, which differ by a unit; also let

$$\triangle=\log.\mathrm{N}'-\log.\mathrm{N}=\log.\frac{\mathrm{N}'}{\mathrm{N}'-100},$$

$$\triangle'=\log.\mathrm{N}''-\log.\mathrm{N}'=\log.\frac{\mathrm{N}'+100}{\mathrm{N}'},$$

$$d=\log.n'-\log.n=\log.\frac{n'}{n'-1},$$

$$d'=\log.n''-\log.n'=\log.\frac{n'+1}{n'}.$$

Then, rejecting such terms of the logarithmic series as are divided by the fourth and higher powers of N′ and n', on account of their smallness, we have by formula (A) and (B),

$$\triangle=\mathrm{M}\left\{\frac{100}{\mathrm{N}'}+\frac{100^2}{2\mathrm{N}'^2}+\frac{100^3}{3\mathrm{N}'^3}\right\}\text{ nearly,}$$

$$\triangle'=\mathrm{M}\left\{\frac{100}{\mathrm{N}'}-\frac{100^2}{2\mathrm{N}'^2}+\frac{100^3}{3\mathrm{N}'^3}\right\}\text{ nearly.}$$

Hence $\triangle-\triangle'=\mathrm{M}\frac{100^2}{\mathrm{N}'^2}$ nearly, and $\frac{\triangle-\triangle'}{10000}=\frac{\mathrm{M}}{\mathrm{N}'^2}$.

In like manner we have $d-d'=\frac{\mathrm{M}}{n'^2}$; therefore

$$d-d'=\frac{\triangle-\triangle'}{10000}-\mathrm{M}\left\{\frac{1}{n'2}-\frac{\mathrm{N}'^2}{1}\right\}.$$

The quantity $\frac{1}{n'^2}-\frac{1}{\mathrm{N}'^2}$ is greatest when N′ and n' are the smallest; that is, when $\mathrm{N}'=10100$ and $n'=10000$, in which case it is less than .0000000002; therefore it may be neglected, and we may reckon

$$d-d'=\frac{\triangle-\triangle'}{100000}\text{ very nearly.}$$

Again, because

$$\log.(\mathrm{N}+1)=\log.(\mathrm{N}'-99)=\log.\mathrm{N}'+\log.\left(1-\frac{99}{\mathrm{N}'}\right)$$

$$=\log.\mathrm{N}'-\mathrm{M}\left\{\frac{99}{\mathrm{N}'}+\frac{99^2}{2\mathrm{N}'^2}+,\&c.\right\}$$

and similarly,

$$=\log.(\mathrm{N}'-100)=\log.\mathrm{N}'-\mathrm{M}\left\{\frac{100}{\mathrm{N}'}+\frac{100^2}{2\mathrm{N}'^2}+,\&c.\right\}$$

by subtracting, and rejecting the terms divided by the third and higher powers of N′, we have

$$\log.(\mathrm{N}+1)-\log.\mathrm{N}=\mathrm{M}\left\{\frac{1}{\mathrm{N}'}-\frac{199}{2\mathrm{N}'^2}\right\}\text{ nearly.}$$

But from what has been found above, it appears that

$$\frac{\triangle}{100}=\mathrm{M}\left\{\frac{1}{\mathrm{N}'}+\frac{100}{2\mathrm{N}'^2}\right\}\text{ nearly:}$$

therefore, $\log.(\mathrm{N}+1)-\log.\mathrm{N}-\frac{\triangle}{100}=\frac{99\mathrm{M}}{2\mathrm{N}'^2}$.

But $\frac{\triangle-\triangle'}{10000}=\frac{\mathrm{M}}{\mathrm{N}'^2}$; therefore, eliminating $\frac{\mathrm{M}}{\mathrm{N}'^2}$ by these two equations, we obtain $\log.(\mathrm{N}+1)-\log.\mathrm{N}=\frac{\triangle}{100}+\frac{49.5(\triangle-\triangle')}{10000}$.

Now, since by supposition $d'=\log.n''-\log.n'$, it is evident that

$$\log.n''=\log.n'+d'=\log.n'+d-(d-d')$$

$$=\log.n'+d-\frac{\triangle-\triangle'}{10000};$$

and since $d=\log.n'-\log.n$, if we suppose $n=\mathrm{N}$, we have $d=\log.(\mathrm{N}+1)-\log.\mathrm{N}$; if we suppose $n=\mathrm{N}+1$, then $d=\log.(\mathrm{N}+2)-\log.(\mathrm{N}+1)$; and so on. From these two formulæ, therefore, viz.

$$\log.(\mathrm{N}+1)=\log.\mathrm{N}+\frac{\triangle}{100}+\frac{49.5(\triangle-\triangle')}{10000},$$

$$\text{and }\log.n''=\log.n'+d-\frac{\triangle-\triangle'}{10000},$$

we obtain the following rule for computing logarithms from one another.

1. Let N, N′, N″ be any three numbers in arithmetical progression, not less than 10000 each, and having 100 for their common difference.

2. Find $\triangle=\log.\mathrm{N}'-\log.\mathrm{N}$ and $\triangle'=\log.\mathrm{N}''-\log.\mathrm{N}'$, also $\triangle-\triangle'$.

3. Compute the quantity

$$\frac{49.5(\triangle-\triangle')}{10000}+\frac{\triangle}{100};$$

this will be the difference between the logarithms of N and N+1.

4. From this last difference let the numerical value of $\frac{\triangle-\triangle'}{10000}$ be continually subtracted; that is, first from the difference itself, then from the remainder, then from the next remainder, &c.

5. To the logarithm of N add the difference, then the first remainder, then the next remainder, &c. and the several sums thus arising will be the logarithms of N+1, N+2, N+3, &c. respectively.

Example. Having given the logarithms of 17900, 18000, and 18100, to find the logarithms of all the intermediate numbers.

In this case,

	Logarithms.
$N = 17900$	4.252853031
$N' = 18000$	4.255272505
$N'' = 18100$	4.257678575

$\Delta = .002419474$

$\Delta' = .002406070$ $\qquad \Delta - \Delta' = .000013404$

$d - d' = .0000000134$;

$$\frac{49\ 5(\Delta - \Delta')}{10000} + \frac{\Delta}{100} = .00002426107.$$

The remainder of the operation may stand thus:

		4.252853031	log. 17900
.00002426107		2426107	
134			
		4.25287729207	log. 17901
25973	1st Rem.	2425973	
134			
		4.25290155180	log. 17902
25839	2d Rem.	2425839	
134			
		4.25292581019	log. 17903
25705	3d Rem.	2425705	
134			
		4.25295006724	log. 17904
25571	4th Rem.	2425571	
134			
		4 25297432295	log. 17905
25437	5th Rem.	2425437	
134			
		4.25299857732	log. 17906
25303	6th Rem.	2425303	
134			
		4.25292283035	log. 17907
25169	7th Rem.	2425169	
134			
		4.25294708204	log. 17908
25035	8th Rem.	2425035	
134			
		4.25297133239	log. 17909
24901	9th Rem.	2424901	
&c.			
		4.25299558140	log. 17910
		&c.	

The logarithms found according to this method, in numbers between 100000 and 200000, are true to 8 or 9 places of figures. Those of numbers between 200000 and 300000 err only in the ninth or tenth place, and those above 500000 are true to ten places at least.

22. In our treatise on Fluxions, we have investigated formulæ entirely different from any that we have yet given here for finding the logarithms of numbers. Supposing n to denote an infinitely great number, we have shewn (Art. 38, Fluxions,) that

$$\text{Nap. log. } x = n\left(x^{\frac{1}{n}} - 1\right).$$

At first sight this formula may appear useless, because of the impossibility of computing its numerical value. But it may be transformed into others, in which the infinite or indefinite quantity n shall entirely disappear. We have shewn, (Fluxions, Art. 38.) that, n being any power of 2,

$$x - 1 = \left(x^{\frac{1}{n}} - 1\right)\left(x^{\frac{1}{2}} + 1\right)\left(x^{\frac{1}{4}} + 1\right)\left(x^{\frac{1}{8}} + 1\right) \ldots \times \left(x^{\frac{1}{n}} + 1\right)$$

the number of factors of the form $x^{\frac{1}{n}} + 1$ being always equal to the index of the power of 2 denoted by n: hence we have

$$n\left(x^{\frac{1}{n}} - 1\right) = (x - 1)\frac{2}{x^{\frac{1}{2}} + 1} \cdot \frac{2}{x^{\frac{1}{4}} + 1} \cdot \frac{2}{x^{\frac{1}{8}} + 1} \cdots \times \frac{2}{x^{\frac{1}{n}} + 1}$$

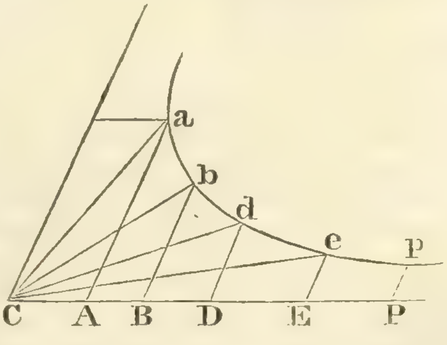
When n is infinite, the first member becomes Napier's logarithm of x, and thus we have

$$\text{Nap. log. } x = (x - 1)\frac{2}{x^{\frac{1}{2}} + 1} \cdot \frac{2}{x^{\frac{1}{4}} + 1} \cdot \frac{2}{x^{\frac{1}{8}} + 1}, \text{ \&c.}$$

The number of factors in the second member is infinite, but they converge continually to $\frac{2}{2} = 1$. This is an elegant analytic expression for a logarithm, but unless x be very nearly equal to 1, its numerical computation would be laborious, unless some artifice were employed.

We have given other analytic formulæ by which the expression $n\left(x^{\frac{1}{n}} - 1\right)$, and consequently Napier's logarithm of x, may be computed, in Fluxions, Art. 11. and 38. To these we refer the mathematical reader; also to a memoir on the quadrature of the conic sections, by Mr. W. Wallace, in the 5th vol. of the *Edin. Phil. Trans.* These are the formulæ to which we have alluded in Algebra, Art. 350.

23. We have stated (sect. 1.) that the first great improvement in the calculation of logarithms was made in consequence of the discovery of their analogy with hyperbolic sectors, and the application of the modern analysis to the quadrature of curves. To explain this analogy: Let C be the centre, and CH, CK, the asymptotes of any hyperbola. In one of these, take CA, CB, CD, CE, &c. continual proportionals; draw A *a*, B *b*, D *d*, E *e*, &c. parallel to the other asymptote, meeting the curve in *a*, *b*, *d*, *e*, &c. and join C *a*, C *b*, C *d*, C *e*, &c. The sectors *a* C *b*, *b* C *d*, *d* C *e*, &c. are equal among themselves, (Conic Sections, sect. iii. prop. 34.) and so also are the hyperbolic areas, A *a b* B, B *b d* D, D *d e* E, &c. (Prop. 33.) Hence, corresponding to the magnitudes CA, CB, CD, CE, &c. which constitute a geometrical progression, the sectors *a* C *b*, *a* C *d*, *a* C *e*, &c. also their equals, the spaces *a* A B *b*, *a* A D *d*, *a* A E *e*, &c. form an arithmetical progression, so that the two series are related to each other exactly in the same manner as numbers and their logarithms. There-



fore, supposing unity to be represented by any abscissa CA, and any other two numbers by the abscissæ CB, CP, and drawing the ordinates, the hyperbolic spaces A a p P, B b p P, or any numbers proportional to them, will be the logarithms of $\frac{\text{CP}}{\text{CA}}$ and $\frac{\text{CP}}{\text{CB}}$ respectively.

Let M be the *modulus* of the system of logarithms expressed by the hyperbolic sectors or trapeziums, and let CA $= m$, C $a = n$, AP $= x$. Then A a p P $=$ M $\times$ Nap. Log. $\left(\frac{m+x}{m}\right)$.

Now, the hyperbolic trapezium A a p P is manifestly greater than a parallelogram whose sides are AP and P p, but less than a parallelogram whose sides are AP, and A a. Putting c for the sine of the angle HCK, and observing that P $p = \frac{mn}{m+x}$ (Conic Sections, Sect. III. Prop. 19. Cor. 2.) the former parallelogram is equal to $\frac{c\,m\,n\,x}{m+x}$, and the latter to $c\,n\,x$; therefore, we have

$$\text{M} \times \text{Nap. log.}\ \frac{m+x}{m} > \frac{c\,m\,n\,x}{m+x}$$

$$\text{M} \times \text{Nap. log.}\ \frac{m+x}{m} < c\,n\,x.$$

This is true, whatever be the magnitude of x. Now,

$$\text{Nap. log.}\ \frac{m+x}{m} = \frac{x}{m} - \frac{x^2}{2\,m^2} +, \&\text{c}$$

$$\frac{c\,m\,n\,x}{m+x} = c\,n\,x - \frac{c\,n\,x^2}{m} +, \&\text{c}.$$

Hence $\frac{\text{M}\,x}{m} - \frac{\text{M}\,x^2}{2\,m^2} +$, &c. is always greater than $c\,n\,x - \frac{c\,n\,x^2}{m} +$, &c. but less than $c\,n\,x$; and dividing by x, we have $\frac{\text{M}}{m} - \frac{\text{M}\,x}{2\,m^2} +$, &c. greater than the whole series $c\,n - \frac{c\,n\,x}{m} +$, &c. but less than $c\,n$, its first term. This can only happen when $\frac{\text{M}}{m}$, the constant part of the one series, is equal to $c\,n$, the constant part of the other series; for x may be taken so small, that the amount of all the other terms in each series shall be less than any assignable quantity; therefore $\frac{\text{M}}{m}$ must be equal to $c\,n$, and M $= c\,m\,n$. This expression for the modulus is the area of the parallelogram A a LC, formed by the co-ordinates A a, a L, and the asymptotes, which is always a given space in a given hyperbola, (Conic Sections, sect. iii. prop. 19. cor. 1.) If A $c = 1$, then the numerical value of the perpendicular of the parallelogram will be the modulus of the system. If the system be that of Napier, in which M $= 1$, the perpendicular of the parallelogram will be equal to its base; but if it be that of Briggs, then M $= .43429448$, and the perpendicular will be to the base as this fraction to unity.

Hence it appears that the name *hyperbolic* logarithms, frequently given exclusively to those invented by Napier, is alike applicable to all, since all may be expressed by hyperbolic areas.

In Conic Sections, sect. 7, we have given formulæ for the computation of hyperbolic areas. These will apply to the computation of logarithms; and, in fact, they are identical with those which we have investigated upon principles purely analytical, in Fluxions, art. 11 and 38.

24. The problem, to find a logarithm from its number, has its reverse; namely, to find a number from its logarithm.

Let a be the radical number of the system, (Algebra, art. 330 and 335), x any number, and y its logarithm. Then, in the equation $x = a^y$, we have a and y given to find x. If y be a small whole number, there is no difficulty; but, in general, y is a number expressed by eight or more figures. In such a case, we may apply the developement of an exponential quantity, which has been investigated in Algebra, (art. 355): this, by putting M for the *modulus* of the system, and making the necessary substitutions, gives

$$x = 1 + \frac{\text{log.}\ x}{\text{M}} + \frac{\text{log.}^2 x}{1.2.\text{M}^2} + \frac{\text{log.}^3 x}{1.2.3\text{M}^3}, \&\text{c}.$$

If $\frac{\text{log.}\ x}{\text{M}}$ be considerable, this series will converge very slow; but we can always find x nearly from a table of logarithms; and then from this series we can find the small correction that it wants. Let a be an approximate value of x found from the table. Put $\frac{x}{a}$ instead of x in the series, and log. x — log. a instead of log. x, we thus get

$$\frac{x}{a} = 1 + \frac{\text{log.}\ x - \text{log.}\ a}{\text{M}} + \frac{(\text{log.}\ x - \text{log.}\ a)^2}{1.2\text{M}^2} +, \&\text{c}.$$

$$\text{and } x = a + \frac{a(\text{log.}\ x - \text{log.}\ a)}{\text{M}} + \frac{a(\text{log.}\ x - \text{log.}\ a)^2}{1.2.\text{M}^2} +, \&\text{c}.$$

If d be put for log. x—log. a, we have

$$x = a + \frac{a\,d}{\text{M} - \frac{1}{2}d} \text{ nearly.}$$

This will readily appear if the fraction be converted into a series.

SECTION III.

Logarithmic Arithmetic.

In order to apply logarithms to the operations of arithmetic, the arrangement of the table must be understood; also, how to find the logarithm to any given number, and, reversely, the number to any given logarithm.

Description of the Table.

In the system of logarithms now commonly used, the logarithm 1 being 0, that of 10 is 1. Hence the logarithm of 100 is 2, that of 1000 is 3, and so on. On the other hand, the logarithm of .1 is—1, (that is, 1, considered as subtractive,) the logarithm of .01 is—2, that of .001 is —3, and so on. As it is only the terms of the geometrical progression 1, 10, 100, 1000, &c. continued forward, or 1, .1, .01, .001, &c. continued backwards, that have their logarithms expressed by integers, the logarithms of the intermediate numbers will be expressed by decimal fractions, preceded by a cypher or an integer. Thus all numbers between 1 and 10 will be between 0 and 1; the logarithms of all numbers between 10 and 100 will be between 1 and 2, &c.; also the logarithms of all fractions between 1 and .1 will be between 0 and —1; the logarithms of all fractions between .1 and .01 will be between —1 and —2, &c.

However, instead of expressing the logarithms of proper fractions by quantities entirely negative, it is usual to make the fractional part positive, and the integer negative. Thus, if the logarithm were —2.36285, a quantity entirely subtractive, it is usual to make it —3+1—.36285; that is, —3+.63715, which is sometimes written thus, 3.63715, the negative sign being placed over the subtractive part. Frequently, however, it is expressed thus, —3.63715, it being understood that the integer is negative, and the fraction positive. In the examples which follow, we shall adopt the first of these two methods.

In this way, the logarithms of all numbers expressed by the same figures, and only differing by the position of the decimal point, will be the same in the decimal part, but will differ in the integers, as in the following examples:

Numbers.	Logarithms.
1240	3.09342
124	2.09342
12.4	1.09342
1.24	0.09342
.124	$\bar{1}$.09342
.0124	$\bar{2}$.09342
.00124	$\bar{3}$.09342

The integer figure, whether positive or negative, in each logarithm, is called its *index, or characteristic. It is always less by one than the number of integer figures which the natural number consists of; or it expresses how many places the digit in the highest place stands to the right or left of the place of units.* Thus, in the number 1240, the highest figure (viz. 1) is three places from the units place to the left, and the index of the log. is 3. In 00124, the highest figure is two places to the right of the units place, and the index is —2.

The Table exhibits the logarithms of all numbers from 1 to 10000, with their differences, by which the logarithm of any number or decimal fraction consisting of five figures may be easily found.

1. *To find the logarithm of any number consisting of four or fewer figures.*

Look for the number in the columns marked N. at the top, and opposite will be found the decimal part of the logarithm sought, to which the decimal point and index found by the preceding rule must be prefixed. In this way the logarithms which follow have been found.

Numbers.	Logarithms.
7·	0.84510
19.	1.27875
4.35	0.63849
1620	3.20952
32000	4.50515
.4326	$\bar{1}$.63609
001682	$\bar{3}$.22583

2. *To find the logarithm of a number consisting of five figures.*

Find the decimal part of the logarithm of the first four figures of the number, (that is, find its logarithm as if the last figure was a cipher,) by the last rule; then state this proportion:

As 10 to the tabular difference, so is the last figure of the number to a fourth proportional; which being added to the former logarithm, and the index and decimal point supplied, will be the logarithm required.

Example.—To find the logarithm of 312.78. The decimal part of the logarithm of the first four figures, viz. of 3127, is .49513. The difference between this and the next higher logarithm is 14. The proportion will be

$$10:14::8:\frac{8\times14}{10}=11.2.$$

The fourth proportional is 11.2, or 11 nearly. This added to .49513, and the index 2 supplied, gives 2.49524 for the logarithm of 312.78.

3. *To find the logarithm of a vulgar fraction, or mixed number.*

Either reduce the vulgar fraction to a decimal, and find its logarithm by rule 2d; or else subtract the logarithm of its denominator from that of its numerator, and the remainder will be the logarithm sought. The fractional part of a mixed number may be reduced to a decimal, or else it may be reduced to an improper fraction, and the rule applied.

Ex. 1. To find the logarithm of $\frac{5}{8}$. This fraction reduced to a decimal is .625; the logarithm of which is $\bar{1}$.79588; or thus:

From log. 5 . . . . . 0.69897
Subtract log. 8 . . . . 0.90309

Rem. log. $\frac{5}{8}$ . . . . . . $\bar{1}$.79588

Here, as the lower number is greater than the upper, the remainder must be negative. The subtraction, however, is so performed, that the decimal part of the remainder is positive, and the index negative.

Ex. 2. To find the logarithm of $13\frac{3}{4}=\frac{55}{4}=13.75$.

From log. 55 . . . . . . 1.74036
Sub. log. 4 . . . . . . 0.60206

Rem. log. $13\frac{3}{4}=13.75$ . . 1.13830

4. *To find the number corresponding to a given logarithm.*

Seek the decimal part of the proposed logarithm in the column of logarithms; and if it be found exactly, the number opposite to it in the column of numbers is that sought. If the index of the logarithm be 3, the four figures of the number thus found are integers; but if it be 2, the three first figures are integers, and the fourth a decimal, and so on; the number of integer figures being always one less than the index, if it be positive; but if it be negative, the number sought will be a decimal, and the number of ciphers between the decimal point and the first significant figure will be one less than the index.

Examples.

Logarithms.	Numbers.
3.63022	4268
4.87128	74350
1.40449	25.38
$\bar{2}$.15412	.01426

When a given logarithm is not found in the table, subtract the next less tabular logarithm from it, and take the difference between that logarithm and the next greater, as given in the column of differences; then make this proportion:

As the tabular difference is to 10, so is the difference between the given logarithm and the next less to a fourth proportional; which being annexed to the four figures corresponding to the logarithm next less, will be the number required.

Example. To find the number where the logarithm is 3.32682.

The decimal part of the given log. is . .	.32682
That of the next less, viz. of log. 2122, is	.32675
	7

The tabular difference is 20:

$$20 : 10 : : 7 : \frac{7\times10}{20} = 3 \text{ nearly.}$$

The number corresponding to the given logarithm is 2122.3.

Note. The table of the logarithms of numbers is followed by a *table of logarithmic sines and tangents for every minute of the quadrant, with their differences.* Its application will be given in TRIGONOMETRY.

MULTIPLICATION BY LOGARITHMS.

RULE.—Add together the logarithms of the factors; their sum will be the logarithm of the product, and the number in the table corresponding to that logarithm will be the product.

Note.—If some of the indices be positive, and others negative, the positive indices, and the number carried from the decimal part, must be added into one sum, and the negative indices into another: the difference of these will be the index of the logarithm of the product, and it will be positive or negative, according as the sum of the positive indices is greater or less than the sum of the negative.

Ex. 1. To multiply 2.314 by 50.62.

	Numbers.	Logarithms.
	2.314	0.36436
	50.62	1.70432
Product .	117.13	2 06868

Ex. 2. To find the continual product of 39.02, and 597.96, and .03147.

	Numbers.	Logarithms.
	39.02	1.59129
	597.16	2.77609
	.03147	$\bar{2}.49790$
Product .	733.3	2.86528

Ex. Required the continual product of 3.586, 2.1046, 0.8372, and 0.0294.

	Numbers.	Logarithms.
	3 586	0.55461
	2.1046	0.32317
	0.8372	$\bar{1}.92283$
	0.0294	$\bar{2}.46835$
Product .	.18576	$\bar{1}.26896$

In the second example, the sum of the positive indices and 1 carried, exceeds the negative index by 2; the index of the logarithm of the product is therefore +2 or 2. The reverse is the case in the third example, and therefore the index is negative.

DIVISION BY LOGARITHMS.

RULE.—Subtract the logarithm of the divisor from the logarithm of the dividend; the remainder is the logarithm of the quotient, and the corresponding number is the quotient.

Observing to change the sign of the index of the divisor from positive to negative, or from negative to positive, then take the sum of the indices, if they be of the same name, or their difference, if they have different signs, with the sign of the greater, for the index to the logarithm of the quotient.

Also, when 1 is borrowed in the left-hand place in the decimal part of the logarithm, add it to the index of the divisor when that index is positive, but subtract it when negative; then let the index arising from thence be changed, and work as before.

Ex. 1. Divide 24163 by 4567.

	Numbers.	Logarithms.
Dividend . . .	24163	4.38315
Divisor	4567	3.65963
Quotient . . .	5.2908	0.72352

Ex. 2. Divide 37.15 by 523.76

	Numbers.	Logarithms.
	37.15	1 56996
	523.76	2.71913
Quotient . .	.07093	2.85083

Here 1, carried from the decimal part of the divisor, is added to 2, the index; and the sum, + 3, is changed to —3: this having a different sign from the index of the dividend, their difference 2 is taken, and the sign of the greater (which is —) is joined to 2, the remainder.

Ex. 3. Divide .06314 by .007241.

	Numbers.	Logarithms.
	.06314	$\bar{2}.80030$
	.007241	$\bar{3}.85980$
Quot	8.72	0.94050

Here 1 carried from the decimals to —3, makes it —2. which, taken from the other —2, leaves 0 remaining.

Ex. 4. Divide .7438 by 12.947.

	Numbers.	Logarithms.
	.7438	1.87146
	12.947	1.11217
Quot.	.05745	$\bar{2}.75929$

Here the sign of the index of the divisor being changed to — 1, the sum is to be taken which gives.

PROPORTION BY LOGARITHMS.

Rule.—Add together the logarithms of the second and third term, and from the sum subtract the logarithm of the first term, the remainder will be the logarithm of the fourth term, or answer; or in any compound proportion, add together the logarithms of all the terms to be multiplied, and from that sum subtract the sum of the others, the remainder will be the logarithm of the answer.

Note.—Instead of subtracting any logarithm, its *arithmetical complement* may be added, and the result will be the same. The arithmetical complement is the logarithm of the reciprocal of the given number; or rather, that reciprocal multiplied by the tenth power of 10. It is found by subtracting the logarithm from 10, and this is most easily done by subtracting each significant figure from 9, except the last, which must be subtracted from 10. But when the index is negative, add it to 9, and subtract the rest as before; and for every complement that is added, reject 10 from the last sum of the indices.

Ex. 1. Find a fourth proportional to 72.34, 2.519, and 357.48.

Numbers.	Logarithms.
As 72.34	1.85938
To 2.519	0.40123
So is 357.48	2.55325
	2.95448
To 12.448	1.09510

Here the logarithms of the second and third terms are added, and the logarithm of the first term is subtracted from the sum. By adding the arithmetical complement of the first term, it might otherwise have been expressed thus:

As 72.34	Ar. comp. log.	8.14062
To 2.519		0.40123
So is 357.48		2.55325
To 12.448		1.09510

In adding, 10 is rejected from the sum of the indices, on account of the arithmetical complement.

Ex. 2. Find a fourth proportional to .0649, .85132, and .37914.

As .0649	Ar. comp. log.	11.18776
To .85132		$\bar{1}$.93009
So is .37914		$\bar{1}$.57880
To 4.9733		0.69665

Ex. 3. If the interest of 100*l.* for a year, or 365 days, be 4.5*l.*, what will be the interest of 279.25*l.* for 274 days?

As	100 365	Ar. comp. log.	8.00000 7.43771
To	279.25 274		2.44599 2.43775
So is	4.5		0.65321
To	9.4332		0.97466

INVOLUTION, OR RAISING OF POWERS.

Rule.—Multiply the logarithm of the given number by the index of the proposed power, and the product will be the logarithm of the number sought.

Note.—In multiplying a logarithm with a negative index by any affirmative number, the product will be negative; but what is to be carried from the decimal part of the logarithm will be affirmative: Therefore the difference will be the index of the product, and is to be accounted of the same kind with the greater.

Ex. 1. To find the cube of 3.0715.

Root 3.0715	Its log. 0.48735
	3
Power 28.977	1.46205

Ex. 2. To find the fourth power of .09163

Root .09163	$\bar{2}$.96204
	4
Power .000070495	$\bar{5}$.84816

Here 4 times the negative index being —8, and 3 to be carried, the difference —5 is the index of the product.

Ex. 3. What would 1*l.* amount to, if improved at compound interest for 425 years, at 5 per cent.?

By the nature of compound interest, the amount of 1*l.* in any number of years, is its amount in one year raised to a power equal to the number of years.

	Log.
Amount of 1*l.* in one year is 1.05	0.02119
Multiply by	425
	10595
	4238
	8476
1013300000	9.00575

The amount would exceed one thousand millions of pounds, a sum exceeding the national debt.

Evolution or extraction of Roots.

Divide the logarithm of the power or given number by its index, and the quotient will be the logarithm of the root.

Note.—When the index of the logarithm is negative, and the divisor is not exactly contained in it without a remainder, increase it by such a number as will make it exactly divisible, and carry the units borrowed as so many terms to the left-hand place of the decimal part of the logarithm; then divide the results by the index of the root.

Ex. 1. Find the square root of 365.

Power 365	2)2.56229
Root 19.105	1.28114

Ex. 2. Find the square root of .093.

Power .093	2)$\bar{2}$.96848
Root .30496	$\bar{1}$.48424

Here the divisor 2 is contained exactly once in $\bar{2}$, the negative index; therefore the index of the quotient is $\bar{1}$.

Ex. 3. Find the cube root of .00048.

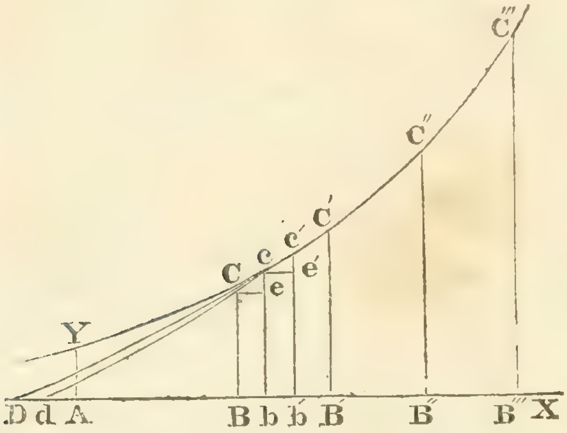
Power .00048	3)4.68124
Root .078298	$\bar{2}$.89375

Here the divisor 3 not being exactly contained in $\bar{4}$, augment it by 2, to make it become $\bar{6}$, in which the divisor is contained just 2 times ; and then 2 borrowed, being carried to the other figures 6, &c. makes 2.68124, which, divided by 3, gives .89375.

Logarithmic Curve.

Let a straight line AX be assumed as an axis, and a given point, A, in that line, as the origin of co-ordinates. At any equal distances, BB′, B′B″, B″B‴, erect perpendiculars, Bc, B′c′, B″c″, B‴c‴, &c. ; so as to form a continued geometrical progression ; that is, Bc : B′c′ : : B′c′ : B″c″ : : B″c″ : B‴c‴, &c. Then c, c′, c″, c‴, &c. the tops of the perpendiculars, will be in a line called the *logarithmic* curve, and sometimes the *logistic* curve.

If the distances BB′, B′B″, &c. be bisected, and perpendiculars be erected which are geometrical means between those on each side, their tops will be also in the curve ; and, in this way, any number of points in it whatever may be assigned.



It is evident that the numbers which express the abscissæ AB, AB′, AB″, &c. are the logarithms of the numbers which express the ordinates Bc, B′c′ B″c″. &c. Hence the origin of the name. The more important properties of the curve are the following :

1. The axis AX is an asymptote to the curve ; for, supposing the ordinate AY to represent an unit, those on one side will go on continually increasing, and those on the other side will continually decrease, and at last may become less than any assignable quantities, without absolutely becoming =0.

2. If a tangent CD be drawn, meeting the axis on D, the subtangent BD will be always of the same magnitude. For let Bc, bc, b′c′, be ordinates indefinitely near, and at equal distances; draw the tangent cd, and ce, c′e′, parallel to the axis. Then, because the ordinates are equally distant, they are continual proportionals ; therefore

$$BC : bc : : bc : b'c' : : bc—BC : b'c'—bc : : ce : c'e'.$$

$$\text{But } ce = \frac{BC}{DB} \times Ce \text{ and } c'e' = \frac{bc}{db} \times c'e' = \frac{bc}{db} \times ce.$$

$$\text{Hence } BC : bc : : \frac{BC}{DB} : \frac{bc}{db};$$

therefore DB=db: thus it appears that the subtangent DB has always the same magnitude.

3. By the nature of the curve, $x = \log. y$; hence its equation is $y = a^x$, a being a constant quantity.

The co-ordinates of this curve exhibit geometrically the relation between numbers and their logarithms.—See COMMON LOGARITHMS, BINARY, and EULER'S LOGARITHMS, and HYPERBOLIC LOGARITHMS.

LOGARITHMS LOGOMETRIC, or the logarithms of logarithms. It is mentioned in the *Phil. Mag.* vol. xlv. p. 387, that since the year 1807, Mr. Farey has been in the habit of using this species of logarithms in his musical calculations ; very numerous results of which have appeared in our work. The following Table cannot fail of proving highly useful to musical calculators.

	Names of Intervals.	Farey's Notations.			His Logometric logs.
		Σ	f	m	
l	Minor First, or Unison - -	0	0	0	0.0000000
m	Subminimum Comma, or *Minute* - - - - - -	0	0	1	1.5858464
n	Minor Difference - - -	0	2	—1	3.1548692
f	Subminimum Residual, or lesser *Fraction* - - -	0	1	0	2.8653995
p	Major Difference - - - -	0	3	—1	3.3348483
ı	Medius Fraction - - - -	1	—3	+1	3.4376092
F	Greater Fraction - - - -	1	—1	+1	3.6238803
Σ	Minimum Comma, or *Schisma*	1	0	0	3.6902910
r	Minor Residual - - - -	2	1	0	4.0226610
χ	Medius Residual - - - -	3	1	0	4.1885549
ſc	Lesser Residual, or *Semicomma* major - - - -	4	1	0	4.3083036
ƒc	Major Residual, or *ditto* max.	5	1	0	4.4020697
R	Greater Residual - - - -	5	2	0	4.4145113
R	Major Fraction, or major *Residual* - - - - - -	6	—1	+1	4.4580552
γ	Lesser Comma - - - -	9	0	1	4.6449127
Є	Minor Comma - - - -	10	0	1	4.6906324
φ	Minor Hyperoche, or *Prisma*	10	1	1	4.6970789
c	Major Comma, (or ′, or ‵) -	11	0	1	4.7319940
đ	Maximum Comma, or *Diaschisma* - - - - - -	12	0	1	4.7697567
D	Medius Hyperoche, or *Dieze* min. - - - - - - -	14	1	1	4.8412783
π	Major Hyperoche - - -	15	1	1	4.8709188
ε	Minimum Diesis, or Enharmonic *Diesis* - - -	21	0	2	5.0128354
ℱ	Semitone subminimum - -	25	1	2	5.0910946
δ	Semitone Minimis, or Chromatic *Diesis* - - -	26	1	2	5.1080181
β	Minor Diesis - - - - -	31	0	3	5.1819810
ƒ	Major Diesis, or *Semitone* minimum - - - -	32	0	3	5.1957610
ℐ	Semitone Minor - - - -	36	1	3	5.2486785
△	Greater Diesis - - - -	43	0	4	5.3240770
L	Semitone Lesser, or *Limma*	46	1	4	5.3547554
I	Major *First* - - - - -	47	1	4	5.3640593
S	Semitone Medius - - -	53	0	5	5.4148889
2 S	Minor *Second* Semitone Major (or H) -	57	1	5	5.4476034
P	Semitone Greater, or *Apotome*	58	1	5	5.4551318
§	Semitone Maximum - -	68	1	6	5.5240552
✠	Tone Minimum, (or ♯♯, or ♭♭)	83	2	7	5.6112194
t	Tone Minor - - - - -	93	2	8	5.5604622

	Names of Intervals.	Farey's Notations.			His Logometric logs.
		Σ	f	m	
II T	Major *Second* Tone Major	104	2	9	5.7088671
T	Tone Maximum	115	2	10	5.7524138
3	Minor *Third*	161	3	14	5.8986224
III	Major *Third*	197	4	17	5.9863687
4	Minor *Fourth*	254	5	22	6.0966971
IV	Major *Fourth*	301	6	26	6.1704452
5	Minor *Fifth*	311	6	27	6.1845991
V	Major *Fifth*	358	7	31	6.2457378
6	Minor *Sixth*	415	8	36	6.3098856
VI	Major *Sixth*	451	9	39	6.3460570
7	Minor *Seventh* (or 2·4ths)	508	10	44	6.3977271
VII	Major *Seventh*	555	11	48	6.4361646
8	Minor *Eighth*	565	11	49	6.4438982
VIII	Major *Eighth*, or Octave	612	12	53	6.4786098
XII	Major *Twelfth*, (or VIII + V)	970	19	84	6.6786287
XVII	Major *Seventeenth*, (or 2 VIII + III)	1421	28	123	6.8444585

In the first, second, and third columns of the above Table, the symbols, names, and new notations are given of a more complete table of the chief musical intervals, than is engraven in Plate XXX. of Vol. II. and explained in Apotome; and in the fourth and last column, is now, for the first time, presented to the public the logometric logarithms of these intervals. They have been found by taking the logarithm of the reciprocal common logarithm of the several intervals; and they express *the ratios* of their several magnitudes.

The use of this Table is considerable, in all cases where it is required to calculate how many given times one given interval is contained in another given interval. If, for instance, it be required to show how many schismas (Σ) are contained in the octave, (VIII) the difference of their logometric logarithms is to be taken; thus, 6.4786098—3.6902910=2.7883188 is a common logarithm; the number answering to which will give the required number, or 614.21264 are the schismas in any octave. Again, suppose the small interval (mentioned by Mr. S. Rootsey as the temperament of an isotonic fifth,) having the ratio $\frac{880}{881}$, were given, to determine how many times the same is contained in an octave: first, the reciprocal common log. of this fraction must be sought, which is 4932.3626 in eleven-place logarithms; and the common logarithm of this, viz. 3.6930550, is the logometric logarithm of the given interval, its index being made 3, in order to correspond with 7-place logs. to which the above Table is adapted. Then, 6.4786098 — 3.6930550 = 2.7855548, is a log. answering to 610.3160, the required number of this small interval which make an octave. Lastly, supposing it were required to ascertain how many of M. Poerand's minutes are contained in a minor third, we have the difference of the tabular logs. = 4.3127760, answering to the number 20541.305; and so many of this minute interval will make up the least concord.

In the *Philosophical Transactions* for 1814, Dr. Peter M. Roget has given a very ingenious paper on logometric logarithms, with accurate engravings of several forms of slider rules, divided according thereto, by which great numbers of the most difficult arithmetical operations may be easily wrought, and various kinds of exponential questions solved.

LOGARITHMS OF NUMBERS.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.	N	Log.	N.	Log.	N.	Log.
		60	77815	120	07918	180	25527	240	38021	300	47712	360	55630	420	62325
1	00000	61	78533	121	08279	181	25768	241	38202	301	47857	361	55751	421	62428
2	30103	62	79293	122	08636	182	26007	242	38382	302	48001	362	55871	422	62531
3	47712	63	79934	123	08991	183	26245	243	38561	303	48144	363	55991	423	62634
4	60206	64	80618	124	09342	184	26482	244	38739	304	48287	364	56110	424	62737
5	69897	65	81291	125	09691	185	26717	245	38917	305	48430	365	56229	425	62839
6	77815	66	81954	126	10037	186	26951	246	39094	306	48572	366	56348	426	62941
7	84510	67	82607	127	10380	187	27184	247	39270	307	48714	367	56467	427	63043
8	90309	68	83251	128	10721	188	27416	248	39445	308	48855	368	56585	428	63144
9	95424	69	83885	129	11059	189	27646	249	39620	309	48996	369	56703	429	63246
10	00000	70	84510	130	11394	190	27875	250	39794	310	49136	370	56820	430	63347
11	04139	71	85126	131	11727	191	28103	251	39967	311	49276	371	56937	431	63448
12	07918	72	85733	132	12057	192	28330	252	40140	312	49415	372	57065	432	63548
13	11394	73	86332	133	12385	193	28556	253	40312	313	49554	373	57171	433	63649
14	14613	74	86923	134	12710	194	28780	254	40483	314	49693	374	57287	434	63749
15	17609	75	87506	135	13033	195	29003	255	40654	315	49831	375	57403	435	63849
16	20412	76	88081	136	13354	196	29226	256	40824	316	49969	376	57519	436	63949
17	23045	77	88649	137	13672	197	29447	257	40993	317	50106	377	57634	437	64048
18	25527	78	89209	138	13988	198	29667	258	41162	318	50243	378	57749	438	64147
19	27875	79	89763	139	14301	199	29885	259	41330	319	50379	379	57864	439	64246
20	30103	80	90309	140	14613	200	30103	260	41497	320	50515	380	57978	440	64345
21	32222	81	90849	141	14922	201	30320	261	41664	321	50651	381	58092	441	64444
22	34242	82	91381	142	15229	202	30535	262	41830	322	50786	382	58206	442	64542
23	36173	83	91908	143	15534	203	30750	263	41996	323	50920	383	58320	443	64640
24	38021	84	92428	144	15836	204	30963	264	42160	324	51055	384	58433	444	64738
25	39794	85	92942	145	16137	205	31175	265	42325	325	51188	385	48546	445	64836
26	41497	86	93450	146	16435	206	31387	266	42488	326	51322	386	58659	446	64933
27	43136	87	93952	147	16732	207	31597	267	42651	327	51455	387	58771	447	65031
28	44716	88	94448	148	17026	208	31806	268	42813	328	51587	388	58883	448	65128
29	46240	89	94939	149	17319	209	32015	269	42975	329	51720	389	58995	449	65225
30	47712	90	95424	150	17609	210	32222	270	43136	330	51851	390	59106	450	65321
31	49136	91	95904	151	17898	211	32428	271	43297	331	51983	391	59218	451	65418
32	50515	92	96379	152	18184	212	32634	272	43457	332	52114	392	59329	452	65514
33	51851	93	96848	153	18469	213	32838	273	43616	333	52244	393	59439	453	65610
34	53148	94	97313	154	18752	214	33041	274	43775	334	52375	394	59550	454	65706
35	54407	95	97772	155	19033	215	33244	275	43933	335	52504	395	59660	455	65801
36	55630	96	98227	156	19312	216	33445	276	44091	336	52634	396	59770	456	65896
37	56820	97	98677	157	19590	217	33646	277	44248	337	52763	397	59879	457	65992
38	57978	98	99123	158	19866	218	33846	278	44404	338	52892	398	59988	458	66087
39	59106	99	99564	159	20140	219	34044	279	44560	339	53020	399	60097	459	66181
40	60206	100	00000	160	20412	220	34242	280	44716	340	53148	400	60206	460	66276
41	61278	101	00432	161	20683	221	34439	281	44871	341	53275	401	60314	461	66370
42	62325	102	00860	162	20952	222	34635	282	45025	342	53403	402	60423	462	66464
43	63347	103	01284	163	21219	223	34830	283	45179	343	53529	403	60531	463	66558
44	64345	104	01703	164	21484	224	35025	284	45332	344	53656	404	60638	464	66652
45	65321	105	02119	165	21748	225	35218	285	45484	345	53782	405	60746	465	66745
46	66276	106	02531	166	22011	226	35411	286	45637	346	53908	406	60853	466	66839
47	67210	107	02938	167	22272	227	35603	287	45788	347	54033	407	60959	467	66932
48	68124	108	03342	168	22531	228	35793	288	45939	348	54158	408	61066	468	67025
49	69020	109	03743	169	22789	229	35984	289	46060	349	54283	409	61172	469	67117
50	69897	110	04139	170	23045	230	36173	290	46240	350	54407	410	61278	470	67210
51	70757	111	04532	171	23300	231	36361	291	46389	351	54531	411	61384	471	67302
52	71600	112	04922	172	23553	232	36549	292	46538	352	54654	412	61490	472	67394
53	72428	113	05308	173	23805	233	36736	293	46687	353	54777	413	61595	473	67486
54	73239	114	05690	174	24055	234	36922	294	46835	354	54900	414	61700	474	67578
55	74036	115	06070	175	24304	235	37107	295	46982	355	55023	415	61805	475	67669
56	74819	116	06446	176	24551	236	37292	296	47129	356	55145	416	61909	476	67761
57	75587	117	06819	177	24797	237	37475	297	47276	357	55267	417	62014	477	67852
58	76343	118	07188	178	25042	238	37658	298	47422	358	55388	418	62118	478	67943
59	77085	119	07555	179	25285	239	37840	299	47567	359	55509	419	62221	479	68034
60	77815	120	07918	180	25527	240	38021	300	47712	360	55630	420	62325	480	68124

LOGARITHMS OF NUMBERS.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
480	68124	540	73239	600	77815	660	81954	720	85733	780	89209	840	92428	900	95424
481	68215	541	73320	601	77887	661	82020	721	85794	781	89265	841	92480	901	95472
482	68305	542	73400	602	77960	662	82086	722	85854	782	89321	842	92531	902	95521
483	68395	543	73480	603	78032	663	82151	723	85914	783	89376	843	92583	903	95569
484	68485	544	73560	604	78104	664	82217	724	85974	784	89432	844	92634	904	95617
485	68574	545	73640	605	78176	665	82282	725	86034	785	89487	845	92686	905	95665
486	68664	546	73719	606	78247	666	82347	726	86094	786	89542	846	92737	906	95713
487	68753	547	73799	607	78319	667	82413	727	86153	787	89597	847	92788	907	95761
488	68842	548	73878	608	78390	668	82478	728	86213	788	89653	848	92840	908	95809
489	68931	549	73957	609	78462	669	82543	729	86273	789	89708	849	92891	909	95856
490	69020	550	74036	610	78533	670	82607	730	86332	790	89763	850	92942	910	95904
491	69108	551	74115	611	78604	671	82672	731	86392	791	89818	851	92993	911	95952
492	69197	552	74194	612	78675	672	82737	732	86451	792	89873	852	93044	912	95999
493	69285	553	74273	613	78746	673	82802	733	86510	793	89927	853	93095	913	96047
494	69373	554	74351	614	78817	674	82866	734	86570	794	89982	854	93146	914	96095
495	69461	555	74429	615	78888	675	82930	735	86629	795	90037	855	93197	915	96142
496	69548	556	74507	616	78958	676	82995	736	86688	796	90091	856	93247	916	96190
497	69636	557	74586	617	79029	677	83059	737	86747	797	90146	857	93298	917	96237
498	69723	558	74663	618	79099	678	83123	738	86806	798	90200	858	93349	918	96284
499	69810	559	74741	619	79169	679	83187	739	86864	799	90255	859	93399	919	96332
500	69897	560	74819	620	79239	680	83251	740	86923	800	90309	860	93450	920	96379
501	69984	561	74896	621	79309	681	83315	741	86982	801	90363	861	93500	921	96426
502	70070	562	74974	622	79379	682	83378	742	87040	802	90417	862	93551	922	96473
503	70157	563	75051	623	79449	683	83442	743	87099	803	90472	863	93601	923	96520
504	70243	564	75128	624	79518	684	83506	744	87157	804	90526	864	93651	924	96567
505	70329	565	75205	625	79588	685	83569	745	87216	805	90580	865	93702	925	96614
506	70415	566	75282	626	79657	686	83632	746	87274	806	90634	866	93752	926	96661
507	70501	567	75358	627	79727	687	83696	747	87332	807	90687	867	93802	927	96708
508	70586	568	75435	628	79796	688	83759	748	87390	808	90741	868	93852	928	96755
509	70672	569	75511	629	79865	689	83822	749	87448	809	90795	869	93902	929	96802
510	70757	570	75587	630	79934	690	83885	750	87506	810	90849	870	93952	930	96848
511	70842	571	75664	631	80003	691	83948	751	87564	811	90902	871	94002	931	96895
512	70927	572	75740	632	80072	692	84011	752	87622	812	90956	872	94052	932	96942
513	71012	573	75815	633	80140	693	84073	753	87679	813	91009	873	94101	933	96988
514	71096	574	75891	634	80209	694	84136	754	87737	814	91062	874	94151	934	97035
515	71181	575	75967	635	80277	695	84198	755	87795	815	91116	875	94201	935	97081
516	71265	576	76042	636	80346	696	84261	756	87852	816	91169	876	94250	936	97128
517	71349	577	76118	637	80414	697	84323	757	87910	817	91222	877	94300	937	97174
518	71433	578	76193	638	80482	698	84386	758	87967	818	91275	878	94349	938	97220
519	71517	579	76268	639	80550	699	84448	759	88024	819	91328	879	94399	939	97267
520	71600	580	76343	640	80618	700	84510	760	88081	820	91381	880	94448	940	97313
521	71684	581	76418	641	80686	701	84572	761	88138	821	91434	881	94498	941	97359
522	71767	582	76492	642	80754	702	84634	762	88195	822	91487	882	94547	942	97405
523	71850	583	76567	643	80821	703	84696	763	88252	823	91540	883	94596	943	97451
524	71933	584	76641	644	80889	704	84757	764	88309	824	91593	884	94645	944	97497
525	72016	585	76716	645	80956	705	84819	765	88366	825	91645	885	94694	945	97543
526	72099	586	76790	646	81023	706	84880	766	88423	826	91698	886	94743	946	97589
527	72181	587	76864	647	81090	707	84942	767	88480	827	91751	887	94792	947	97635
528	72263	588	76938	648	81158	708	85003	768	88536	828	91803	888	94841	948	97681
529	72346	589	77012	649	81224	709	85065	769	88593	829	91855	889	94890	949	97727
530	72428	590	77085	650	81291	710	85126	770	88649	830	91908	890	94939	950	97772
531	72509	591	77159	651	81358	711	85187	771	88705	831	91960	891	94988	951	97818
532	72591	592	77232	652	81425	712	85248	772	88762	832	92012	892	95036	952	97864
533	72673	593	77305	653	81491	713	85309	773	88818	833	92065	893	95085	953	97909
534	72754	594	77379	654	81558	714	85370	774	88874	834	92117	894	95134	954	97955
535	72835	595	77452	655	81624	715	85431	775	88930	835	92169	895	95182	955	98000
536	72916	596	77525	656	81690	716	85491	776	88986	836	92221	896	95231	956	98046
537	72997	597	77597	657	81757	717	85552	777	89042	837	92273	897	95279	957	98091
538	73078	598	77670	658	81823	718	85612	778	89098	838	92324	898	95328	958	98137
539	73159	599	77743	659	81889	719	85673	779	89154	839	92376	899	95376	959	98182
540	73239	600	77815	660	81954	720	85733	789	89209	840	92428	900	95424	960	98227

LOGARITHMS OF NUMBERS.

N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.
960	98227		1020	00860	43	1080	03342	41	1140	05690	39	1200	07918	36	1260	10037	35	1320	12057	33	1380	13988	31
961	98272		1021	00903	42	1081	03383	40	1141	05729	38	1201	07954	36	1261	10072	34	1321	12090	33	1381	14019	32
962	98318		1022	00945	43	1082	03423	40	1142	05767	38	1202	07990	37	1262	10106	34	1322	12123	33	1382	14051	31
963	98363		1023	00988	42	1083	03463	40	1143	05805	38	1203	08027	36	1263	10140	35	1323	12156	33	1383	14082	32
964	98408		1024	01030	42	1084	03503	40	1144	05843	38	1204	08063	36	1264	10175	34	1324	12189	33	1384	14114	31
965	98453		1025	01072	43	1085	03543	40	1145	05881	37	1205	08099	36	1265	10209	34	1325	12222	32	1385	14145	31
966	98498		1026	01115	42	1086	03583	40	1146	05918	38	1206	08135	36	1266	10243	35	1326	12254	33	1386	14176	32
967	98543		1027	01157	42	1087	03623	40	1147	05956	38	1207	08171	36	1267	10278	34	1327	12287	33	1387	14208	31
968	98588		1028	01199	43	1088	03663	40	1148	05994	38	1208	08207	36	1268	10312	34	1328	12320	32	1388	14239	31
969	98632		1029	01242	42	1089	03703	40	1149	06032	38	1209	08243	36	1269	10346	34	1329	12352	33	1389	14270	31
970	98677		1030	01284	42	1090	03743	39	1150	06070	38	1210	08279	35	1270	10380	35	1330	12385	33	1390	14301	32
971	98722		1031	01326	42	1091	03782	40	1151	06108	37	1211	08314	36	1271	10415	34	1331	12418	32	1391	14333	31
972	98767		1032	01368	42	1092	03822	40	1152	06145	38	1212	08350	36	1272	10449	34	1332	12450	33	1392	14364	31
973	98811		1033	01410	42	1093	03862	40	1153	06183	38	1213	08386	36	1273	10483	34	1333	12483	33	1393	14395	31
974	98856		1034	01452	42	1094	03902	39	1154	06221	37	1214	08422	36	1274	10517	34	1334	12516	32	1394	14426	31
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979	99078		1039	01662	41	1099	04100	39	1159	06408	38	1219	08600	36	1279	10687	34	1339	12678	32	1399	14582	31
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983	99255		1043	01828	42	1103	04258	39	1163	06558	37	1223	08743	35	1283	10823	33	1343	12808	32	1403	14706	31
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1441	15866	31	1501	17638	29	1561	19340	28	1621	20978	27	1681	22557	26	1741	24080	25	1801	25551	24	1861	26975	23
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1447	16047	30	1507	17811	29	1567	19509	28	1627	21139	26	1687	22712	25	1747	24229	25	1807	25696	24	1867	27114	24
1448	16077	30	1508	17840	29	1568	19535	27	1628	21165	27	1688	22737	26	1748	24254	25	1808	25720	24	1868	27138	23
1449	16107	30	1509	17869	29	1569	19562	28	1629	21192	27	1689	22763	26	1749	24379	25	1809	25744	24	1869	27161	23
1450	16137	30	1510	17898	28	1570	19590	28	1630	21219	26	1690	22789	25	1750	24304	25	1810	25768	24	1870	27184	23
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1472	16791	29	1532	18526	28	1592	20194	28	1652	21801	26	1712	23350	26	1772	24846	25	1832	26293	23	1892	27692	23
1473	16820	30	1533	18554	29	1593	20222	27	1653	21827	27	1713	23376	25	1773	24871	24	1833	26316	24	1893	27715	23
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1479	16997	29	1539	18724	28	1599	20385	27	1659	21985	26	1719	23528	25	1779	25018	24	1839	26458	24	1899	27852	23
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1481	17056	29	1541	1878	28	1601	20439	27	1661	22037	26	1721	23578	25	1781	25066	25	1841	26505	24	1901	27898	23
1482	17085	29	1542	18808	29	1602	20466	27	1662	22063	26	1722	23603	26	1782	25091	24	1842	26529	24	1902	27921	23
1483	17114	29	1543	18837	28	1603	20493	27	1663	22089	26	1723	23629	25	1783	25115	24	1843	26553	23	1903	27944	23
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1487	17231	29	1547	18949	28	1607	20602	27	1667	22194	26	1727	23729	25	1787	25212	25	1847	26647	23	1907	28035	23
1488	17268	29	1548	18977	28	1608	20629	27	1668	22220	26	1728	23754	25	1788	25237	24	1848	26670	24	1908	28058	23
1489	17289	30	1549	19005	28	1609	20656	27	1669	22246	26	1729	23779	26	1789	25261	24	1849	26694	23	1909	28081	22
1490	17319	29	1550	19033	28	1610	20683	27	1670	22272	26	1730	23805	25	1790	25285	25	185	26717	24	1910	28103	23
1491	17348	29	1551	19061	28	1611	20710	27	1671	22298	26	1731	23830	25	1791	25310	24	1851	26741	23	1911	28126	23
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1495	17464	29	1555	19173	28	1615	20817	27	1675	22401	26	1735	23930	25	1795	25406	25	1855	26834	24	1915	28217	23
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1497	17522	29	1557	19229	28	1617	20871	27	1677	22453	26	1737	23980	25	1797	25455	24	1857	26881	24	1917	28262	23
1498	17551	29	1558	19257	28	1618	20898	27	1678	22479	26	1738	24005	25	1798	25479	24	1858	26805	23	1918	28285	22
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1921	28353	22	1981	29688	22	2041	30984	22	2101	32243	20	2161	33465	21	2221	34655	19	2281	35813	19	2341	36940	19
1922	28375	23	1982	29710	22	2042	31006	21	2102	32263	21	2162	33486	20	2222	34674	20	2282	35832	19	2342	36959	18
1923	28398	23	1983	29732	22	2043	31027	21	2103	32284	21	2163	33506	20	2223	34694	19	2283	35851	19	2343	36977	19
1924	28421	22	1984	29754	22	2044	31048	21	2104	32305	20	2164	33526	20	2224	34713	20	2284	35870	19	2344	36996	18
1925	28443	23	1985	29776	22	2045	31069	22	2105	32325	21	2165	33546	20	2225	34733	20	2285	35889	19	2345	37014	19
1926	28466	22	1986	29798	22	2046	31091	21	2106	32346	20	2166	33566	20	2226	34753	19	2286	35908	19	2346	37033	18
1927	28488	23	1987	29820	22	2047	31112	21	2107	32366	21	2167	33586	20	2227	34772	20	2287	35927	19	2347	37051	19
1928	28511	22	1988	29842	21	2048	31133	21	2108	32387	21	2168	33606	20	2228	34792	19	2288	35946	19	2348	37070	18
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1930	28556	22	1990	29885	22	2050	31175	22	2110	32428	21	2170	33646	20	2230	34830	20	2290	35984	19	2350	37107	18
1931	28578	23	1991	29907	22	2051	31197	21	2111	32449	20	2171	33666	20	2231	34850	19	2291	36003	18	2351	37125	19
1932	28601	22	1992	29929	22	2052	31218	21	2112	32469	21	2172	33686	20	2232	34869	20	2292	36021	19	2352	37144	18
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1935	28668	23	1995	29994	22	2055	31281	21	2115	32531	21	2175	33746	20	2235	34928	19	2295	36078	19	2355	37199	19
1936	28691	22	1996	30016	22	2056	31302	21	2116	32552	20	2176	33766	20	2236	34947	20	2296	36097	19	2356	37218	18
1937	28713	22	1997	30038	22	2057	31323	22	2117	32572	21	2177	33786	20	2237	34967	19	2297	36116	19	2357	37236	18
1938	28735	23	1998	30060	21	2058	31345	21	2118	32593	20	2178	33806	20	2238	34986	19	2298	36135	19	2358	37254	19
1939	28758	22	1999	30081	22	2059	31366	21	2119	32613	21	2179	33826	20	2239	35005	20	2299	36154	19	2359	37273	18
1940	28780	23	2000	30103	22	2060	31387	21	2120	32634	20	2180	33846	20	2240	35025	19	2300	36173	19	2360	37291	19
1941	28803	22	2001	30125	21	2061	31408	21	2121	32654	21	2181	33866	19	2241	35044	20	2301	36192	19	2361	37310	18
1942	28825	22	2002	30146	22	2062	31429	21	2122	32675	20	2182	33885	20	2242	35064	19	2302	36211	18	2362	37328	18
1943	28847	23	2003	30168	22	2063	31450	21	2123	32695	20	2183	33905	20	2243	35083	19	2303	36229	19	2363	37346	19
1944	28870	22	2004	30190	21	2064	31471	21	2124	32715	21	2184	33925	20	2244	35102	20	2304	36248	19	2364	37365	18
1945	28892	22	2005	30211	22	2065	31492	21	2125	32736	20	2185	33945	20	2245	35122	19	2305	36267	19	2365	37383	18
1946	28914	23	2006	30233	22	2066	31513	21	2126	32756	21	2186	33965	20	2246	35141	19	2306	36286	19	2366	37401	19
1947	28937	22	2007	30255	21	2067	31534	21	2127	32777	20	2187	33985	20	2247	35160	20	2307	36305	19	2367	37420	18
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1949	28981	22	2009	30298	22	2069	31576	21	2129	32818	20	2189	34025	19	2249	35199	19	2309	36342	19	2369	37457	18
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1952	29048	22	2012	30363	21	2972	31639	21	2132	32879	20	2192	34084	20	2252	35257	19	2312	36399	19	2372	37511	19
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1954	29092	23	2014	30406	22	2074	31681	21	2134	32919	21	2194	34124	19	2254	35295	20	2314	36436	19	2374	37548	18
1955	29115	22	2015	30428	21	2075	31702	21	2135	32940	20	2195	34143	20	2255	35315	19	2315	36455	19	2375	37566	19
1956	29137	22	2016	30449	22	2076	31723	21	2136	32960	20	2196	34163	20	2256	35334	19	2316	36474	19	2376	37585	18
1957	29159	22	2017	30471	21	2077	31744	21	2137	32980	21	2197	34183	20	2257	35353	19	2317	36493	18	2377	37603	18
1958	29181	22	2018	30492	22	2078	31765	20	2138	33001	20	2198	34203	20	2258	35372	20	2318	36511	19	2378	37621	18
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1961	29248	22	2021	30557	21	2081	31827	21	2141	33062	20	2201	34262	20	2261	35430	19	2321	36568	18	2381	37676	18
1962	29270	22	2022	30578	22	2082	31848	21	2142	33082	20	2202	34282	19	2262	35449	19	2322	36586	19	2382	37694	18
1963	29292	22	2023	30600	21	2083	31869	21	2143	33102	20	2203	34301	20	2263	35468	20	2323	36605	19	2383	37712	19
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1968	29403	22	2028	30707	21	2088	31973	21	2148	33203	21	2208	34400	20	2268	35564	19	2328	36698	19	2388	37803	19
1969	29425	22	2029	30728	22	2089	31994	21	2149	33224	20	2209	34420	19	2269	35583	20	2329	36717	19	2389	37822	18
1970	29447	22	2030	30750	21	2090	32015	20	2150	33244	20	2210	34439	20	2270	35603	19	2330	36736	18	2390	37840	18
1971	29469	22	2031	30771	21	2091	32035	21	2151	33264	20	2211	34459	20	2271	35622	19	2331	36754	19	2391	37858	18
1972	29491	22	2032	30792	22	2092	32056	21	2152	33284	20	2212	34479	19	2272	35641	19	2332	36773	18	2392	37876	18
1973	29513	22	2033	30814	21	2093	32077	21	2153	33304	21	2213	34498	20	2273	35660	19	2333	36791	19	2393	37894	18
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1975	29557	22	2035	30856	22	2095	32118	21	2155	33345	20	2215	34537	20	2275	35698	19	2335	36829	18	2395	37931	18
1976	29579	22	2036	30878	21	2096	32139	21	2156	33365	20	2216	34557	20	2276	35717	19	2336	36847	19	2396	37949	18
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1979	29645	22	2039	30942	21	2099	32201	21	2159	33425	20	2219	34616	19	2279	35774	19	2339	36903	19	2399	38003	18
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2441	38757	18	2501	39811	18	2561	40841	17	2621	41847	16	2681	42830	16	2741	43791	16	2801	44731	16	2861	45652	15
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2882	45969	15	2942	46864	15	3002	47741	15	3062	48601	14	3122	49443	14	3182	50270	14	3242	51081	14	3302	51878	13
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2884	46000	15	2944	46894	15	3004	47770	14	3064	48629	14	3124	49471	14	3184	50297	14	3244	51108	13	3304	51904	13
2885	46015	15	2945	46909	14	3005	47784	15	3065	48643	14	3125	49485	14	3185	50311	14	3245	51121	14	3305	51917	13
2886	46030	15	2946	46923	15	3006	47799	14	3066	48657	14	3126	49499	14	3186	50325	13	3246	51135	13	3306	51930	13
2887	46045	15	2947	46938	15	3007	47813	15	3067	48671	15	3127	49513	14	3187	50338	14	3247	51148	14	3307	51943	14
2888	46060	15	2948	46953	14	3008	47828	14	3068	48686	14	3128	49527	14	3188	50352	13	3248	51162	13	3308	51957	13
2889	46075	15	2949	46967	15	3009	47842	15	3069	48700	14	3129	49541	14	3189	50365	14	3249	51175	13	3309	51970	13
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3864	58704	11	3924	59373	11	3984	60032	11	4044	60681	11	4104	61321	10	4164	61951	11	4224	62572	11	4284	63185	10
3865	58715	11	3925	59384	11	3985	60043	11	4045	60692	11	4105	61331	11	4165	61962	10	4225	62583	10	4285	63195	10
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3899	59095	11	3959	59759	11	4019	60412	11	4079	61055	11	4139	61690	10	4199	62315	10	4259	62931	10	4319	63538	10
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4322	63568	11	4382	64167	10	4442	64758	10	4502	65341	9	4562	65916	9	4622	66483	9	4682	67043	9	4742	67596	9
4323	63579	10	4383	64177	10	4443	64768	9	4503	65350	10	4563	65925	10	4623	66492	10	4683	67052	10	4743	67605	9
4324	63589	10	4384	64187	10	4444	64777	10	4504	65360	9	4564	65935	9	4624	66502	9	4684	67062	9	4744	67614	10
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4327	63619	10	4387	64217	10	4447	64807	9	4507	65389	9	4567	65963	10	4627	66530	9	4687	67089	10	4747	67642	9
4328	63629	10	4388	64227	10	4448	64816	10	4508	65398	10	4568	65973	9	4628	66539	10	4688	67099	9	4748	67651	9
4329	63639	10	4389	64237	9	4449	64826	10	4509	65408	10	4569	65982	10	4629	66549	9	4689	67108	9	4749	67660	9
4330	63649	10	4390	64246	10	4450	64836	10	4510	65418	9	4570	65992	9	4630	66558	9	4690	67117	10	4750	67669	10
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4332	63669	10	4392	64266	10	4452	64856	9	4512	65437	10	4572	66011	9	4632	66577	9	4692	67136	9	4752	67688	9
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4335	63699	10	4395	64296	10	4455	64885	10	4515	65466	9	4575	66039	10	4635	66605	9	4695	67164	9	4755	67715	9
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4339	63739	10	4399	64335	10	4459	64924	9	4519	65504	10	4579	66077	10	4639	66643	9	4699	67201	9	4759	67752	9
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4347	63819	10	4407	64414	10	4467	65002	9	4527	65581	10	4587	66153	9	4647	66717	10	4707	67274	10	4767	67825	9
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4349	63839	10	4409	64434	10	4469	65021	10	4529	65600	10	4589	66172	9	4649	66736	9	4709	67293	9	4769	67843	9
4350	63849	10	4410	64444	10	4470	65031	9	4530	65610	9	4590	66181	10	4650	66745	10	4710	67302	9	4770	67852	9
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4369	64038	10	4429	64631	9	4489	65215	10	4549	65792	9	4609	66361	9	4669	66922	10	4729	67477	9	4789	68024	10
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4380	64147		4440	64738		4500	65321		4560	65896		4620	66464		4680	67025		4740	67578		4800	68124	

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4801	68133	9	4861	68673	8	4921	69205	9	4981	69732	8	5041	70252	8	5101	70766	8	5161	71273	9	5221	71775	9
4802	68142	9	4862	68681	9	4922	69214	9	4982	69740	9	5042	73260	9	5102	70774	9	5162	71282	8	5222	71784	8
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4805	68169	9	4865	68708	9	4925	69241	8	4985	69767	8	5045	70386	9	5105	70800	8	5165	71307	8	5225	71809	8
4806	68178	9	4866	68717	9	4926	69249	9	4986	69775	9	5046	70295	8	5106	70808	9	5166	71315	9	5226	71817	8
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4810	68215	9	4870	68753	9	4930	69285	9	4990	69810	9	5050	70329	9	5110	70842	9	5170	71349	8	5230	71850	8
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4815	68260	9	4875	68797	9	4935	69329	9	4995	69854	8	5055	70372	9	5115	70885	8	5175	71391	8	5235	71892	8
4816	68269	9	4876	68806	9	4936	69338	8	4996	69862	9	5056	70381	8	5116	70893	9	5176	71399	9	5236	71900	8
4817	68278	9	4877	68815	9	4937	69346	9	4997	69871	9	5057	70389	9	5117	70902	8	5177	71408	8	5237	71908	9
4818	68287	9	4878	68824	9	4938	69355	9	4998	69880	8	5058	70308	8	5118	70910	9	5178	71416	9	5238	71917	8
4819	68296	9	4879	68833	9	4939	69364	9	4999	69888	9	5059	70406	9	5119	70919	8	5179	71425	8	5239	71925	8
4820	68305	9	4880	68842	9	4940	69373	8	5000	69897	9	5060	70415	9	5120	70927	8	5180	71433	8	5240	71933	8
4821	68314	9	4881	68851	9	4941	69381	9	5001	69906	8	5061	70424	8	5121	70935	9	5181	71441	9	5241	71941	9
4822	68323	9	4882	68860	9	4942	69390	9	5002	69914	9	5062	70432	9	5122	70944	8	5182	71450	8	5242	71950	8
4823	68332	9	4883	68869	9	4943	69399	9	5003	69923	9	5063	70441	8	5123	70952	9	5183	71458	8	5243	71958	8
4824	68341	9	4884	68878	8	4944	69408	9	5004	69932	8	5064	70449	9	5124	70961	8	5184	71466	9	5244	71966	9
4825	68350	9	4885	68886	9	4945	69417	8	5005	69940	9	5065	70458	9	5125	70969	9	5185	71475	8	5245	71975	8
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4830	68395	9	4890	68931	9	4950	69461	8	5010	69984	8	5070	70501	8	5130	71012	8	5190	71517	8	5250	72016	8
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4833	68422	9	4893	68958	8	4953	69487	9	5013	70010	8	5073	70526	9	5133	71037	9	5193	71542	8	5253	72041	8
4834	68431	9	4894	68966	9	4954	69496	8	5014	70018	9	5074	70535	9	5134	71046	8	5194	71550	9	5254	72049	8
4835	68440	9	4895	68975	9	4955	69504	9	5015	70027	9	5075	70544	8	5135	71054	9	5195	71559	8	5255	72057	9
4836	68449	9	4896	68984	9	4956	69513	9	5016	70036	8	5076	70572	9	5136	71063	8	5196	71567	8	5256	72066	8
4837	68458	9	4897	68993	9	4957	69522	9	5017	70044	9	5077	70561	8	5137	71071	8	5197	71575	9	5257	72074	8
4838	68467	9	4898	69002	9	4958	69531	8	5018	70053	9	5078	70569	9	5138	71079	9	5198	71584	8	5258	72082	8
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4841	68494	8	4901	69028	9	4961	69557	9	5021	70079	9	5081	70595	8	5141	71105	8	5201	71609	8	5261	72107	9
4842	68502	9	4902	69037	9	4962	69566	8	5022	70088	8	5082	70603	9	5142	71113	9	5202	71617	8	5262	72116	8
4843	68511	9	4903	69046	9	4963	69574	9	5023	70096	9	5083	70612	9	5143	71122	8	5203	71625	9	5263	72123	8
4844	68520	9	4904	69055	9	4964	69583	9	5024	70105	9	5084	70621	8	5144	71130	9	5204	71634	8	5264	72132	8
4845	68529	9	4905	69064	9	4965	69592	9	5025	70114	8	5085	70629	9	5145	71139	8	5205	71642	8	5265	72140	8
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4853	68601	9	4913	69135	9	4973	69662	9	5033	70183	8	5093	70697	9	5153	71206	8	5213	71709	8	5273	72206	8
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4856	68628	9	4916	69161	9	4976	69688	9	5036	70209	8	5096	70723	8	5156	71231	9	5216	71734	8	5276	72230	9
4857	68637	9	4917	69170	9	4977	69697	8	5037	70217	9	5097	70731	9	5157	71240	8	5217	71742	8	5277	72239	8
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4859	68655	9	4919	69188	9	4979	69714	9	5039	70234	9	5099	70749	8	5159	71257	8	5219	71759	8	5279	72255	8
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5281	72272	8	5341	72762	8	5401	73247	8	5461	73727	8	5521	74202	8	5581	74671	8	5641	75136	7	5701	75595	8
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5283	72288	8	5343	72779	8	5403	73263	9	5463	73743	8	5523	74218	7	5583	74687	8	5643	75151	8	5703	75610	8
5284	72296	8	5344	72787	8	5404	73272	8	5464	73751	8	5524	74225	8	5584	74695	7	5644	75159	7	5704	75618	8
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5286	72313	8	5346	72803	8	5406	73288	8	5466	73767	8	5526	74241	8	5586	74710	8	5646	75174	8	5706	75633	8
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5293	72370	8	5353	72860	8	5413	73344	8	5473	73823	7	5533	74296	8	5593	74764	8	5653	75228	8	5713	75686	8
5294	72378	9	5354	72868	8	5414	73352	8	5474	73830	8	5534	74304	8	5594	74772	8	5654	75236	7	5714	75694	8
5295	72387	8	5355	72876	8	5415	73360	8	5475	73838	8	5535	74312	8	5595	74780	8	5655	75243	8	5715	75702	7
5296	72395	8	5356	72884	8	5416	73368	8	5476	73846	8	5536	74320	7	5596	74788	8	5656	75251	8	5716	75709	8
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5307	72485	8	5367	72973	8	5427	73456	8	5487	73933	8	5547	74406	8	5607	74873	8	5667	76335	8	5727	75793	7
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5311	72518	8	5371	73006	8	5431	73488	8	5491	73965	8	5551	74437	8	5611	74904	8	5671	75366	8	5731	75823	8
5312	72526	8	5372	73014	8	5432	73496	8	5492	73973	8	5552	74445	8	5612	74912	8	5672	75374	7	5732	75831	7
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5314	72542	8	5374	73030	8	5434	73512	8	5494	73989	8	5554	74461	7	5614	74927	8	5674	75389	8	5734	75846	7
5315	72550	8	5375	73038	8	5435	73520	8	5495	73997	8	5555	74468	8	5615	74935	8	5675	75397	7	5735	75853	8
5316	72558	9	5376	73046	8	5436	73528	8	5496	74005	8	5556	74476	8	5616	74943	7	5676	75404	8	5736	75861	7
5317	72567	8	5377	73054	8	5437	73536	8	5497	74013	7	5557	74484	8	5617	74950	8	5677	75412	8	5737	75868	8
5318	72575	8	5378	73062	8	5438	73544	8	5498	74020	8	5558	74492	8	5618	74958	8	5678	75420	7	5738	75876	8
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5323	72616	8	5383	73102	9	5443	73584	8	5503	74060	8	5563	74531	8	5623	74997	8	5683	75458	7	5743	75914	7
5324	72624	8	5384	73111	8	5444	73592	8	5504	74068	8	5564	74539	8	5624	75005	7	5684	75465	8	5744	75921	8
5325	72632	8	5385	73119	8	5445	73600	8	5505	74076	8	5565	74547	7	5625	75012	8	5685	75473	8	5745	75929	8
5326	72640	8	5386	73127	8	5446	73608	8	5506	74084	8	5566	74554	8	5626	75020	8	5686	75481	7	5746	75937	7
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5328	72656	9	5388	73143	8	5448	73624	8	5508	74099	8	5568	74570	8	5628	75035	8	5688	75496	8	5748	75952	7
5329	72665	8	5389	73151	8	5449	73632	8	5509	74107	8	5569	74578	8	5629	75043	8	5689	75504	7	5749	75959	8
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5331	72681	8	5391	73167	8	5451	73648	8	5511	74123	8	5571	74593	8	5631	75059	7	5691	75519	7	5751	75974	8
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5337	72730	8	5397	73215	8	5457	73695	8	5517	74170	8	5577	74640	8	5637	75105	8	5697	75565	7	5757	76020	7
5338	72738	8	5398	73223	8	5458	73703	8	5518	74178	8	5578	74648	8	5638	75113	7	5698	75572	8	5758	76027	8
5339	72746	8	5399	73231	8	5459	73711	8	5519	74186	8	5579	74656	7	5639	75120	8	5699	75580	7	5759	76035	7
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5761	76050	7	5821	76500	7	5881	76945	8	5941	77386	7	6001	77822	8	6061	78254	8	6121	78682	7	6181	79106	7
5762	76057	8	5822	76507	8	5882	76953	7	5942	77393	8	6002	77830	7	6062	78262	7	6122	78689	7	6182	79113	7
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5764	76072	8	5824	76522	8	5884	76967	8	5944	77408	7	6004	77844	7	6064	78276	7	6124	78704	7	6184	79127	7
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5766	76087	8	5826	76537	8	5886	76982	7	5946	77422	8	6006	77859	7	6066	78290	7	6126	78718	7	6186	79141	7
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5768	76103	7	5828	76552	7	5888	76997	7	5948	77437	7	6008	77873	7	6068	78305	7	6128	78732	7	6188	79155	7
5769	76110	8	5829	76559	8	5889	77004	8	5949	77444	8	6009	77880	7	6069	78315	7	6129	78739	7	6189	79162	7
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5771	76125	8	5831	76574	8	5891	77019	7	5951	77459	7	6011	77895	7	6071	78326	7	6131	78753	7	6191	79176	7
5772	76133	7	5832	76582	7	5892	77026	8	5952	77466	8	6012	77902	7	6072	78333	7	6132	78760	7	6192	79183	7
5773	76140	8	5833	76589	8	5893	77034	7	5953	77474	7	6013	77909	7	6073	78340	7	6133	78767	7	6193	79190	7
5774	76148	7	5834	76597	7	5894	77041	7	5954	77481	7	6014	77916	8	6074	78347	8	6134	78774	7	6194	79197	7
5775	76155	8	5835	76604	8	5895	77048	8	5955	77488	7	6015	77924	7	6075	78355	7	6135	78781	8	6195	79204	7
5776	76163	7	5836	76612	7	5896	77056	7	5956	77495	8	6016	77931	7	6076	78362	7	6136	78789	7	6196	79211	7
5777	76170	8	5837	76619	7	5897	77063	7	5957	77503	7	6017	77938	7	6077	78369	7	6137	78796	7	6197	79218	7
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5779	76185	8	5839	76634	7	5899	77078	7	5959	77517	8	6019	77952	8	6079	78383	7	6139	78810	7	6199	79232	7
5780	76193	7	5840	76641	8	5900	77085	8	5960	77525	7	6020	77960	7	6080	78390	8	6140	78817	7	6200	79239	7
5781	66200	8	5841	76649	7	5901	77093	7	5951	77532	7	6021	77967	7	6081	78398	7	6141	78824	7	6201	79246	7
5782	76208	7	5842	76656	8	5902	77100	7	5962	77539	7	6022	77974	7	6082	78405	7	6142	78831	7	6202	79253	7
5783	76215	8	5843	76664	7	5903	77107	8	5963	77546	8	6023	77981	7	6083	78412	7	6143	78838	7	6203	79260	7
5784	76223	7	5844	76671	7	5904	77115	7	5964	77554	7	6024	77988	8	6084	78419	7	6144	78845	7	6204	79267	7
5785	76230	8	5845	76678	8	5905	77122	7	5965	77561	7	6025	77996	7	6085	78426	7	6145	78852	7	6205	79274	7
5786	76238	7	5846	76686	7	5906	77129	8	5966	77568	8	6026	78003	7	6086	78433	7	6146	78859	7	6206	79281	7
5787	76245	8	5847	76693	8	5907	77137	7	5967	77576	7	6027	78010	7	6087	78440	7	6147	78866	7	6207	79288	7
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5793	76290	8	5853	76738	7	5913	77181	7	5973	77619	8	6033	78053	8	6093	78483	7	6153	78909	7	6213	79330	7
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5795	76305	8	5855	76753	7	5915	77195	8	5975	77634	7	6035	78068	7	6095	78497	7	6155	78923	7	6215	79344	7
5796	76313	7	5856	76760	8	5916	77203	7	5976	77641	7	6036	78075	7	6096	78504	8	6156	78930	7	6216	79351	7
5797	76320	8	5857	76768	7	5917	77210	7	5977	77648	8	6037	78082	7	6097	78512	7	6157	78937	7	6217	79358	7
5798	76328	7	5858	76775	7	5918	77217	8	5978	77656	7	6038	78089	8	6098	78519	7	6158	78944	7	6218	79365	7
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5801	76350	8	5861	76797	8	5921	77240	7	5981	77677	8	6041	78111	7	6101	78540	7	6161	78965	7	6221	79386	7
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5803	76365	8	5863	76812	7	5923	77254	8	5983	77692	7	6043	78125	7	6103	78554	7	6163	78979	7	6223	79400	7
5804	76373	7	5864	76819	8	5924	77262	7	5984	77699	7	6044	78132	8	6104	78561	8	6164	78986	7	6224	79407	7
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5806	76388	7	5866	76834	8	5926	77276	7	5986	77714	7	6046	78147	7	6106	78576	7	6166	79000	7	6226	79421	7
5807	76395	8	5867	76842	7	5927	77283	8	5987	77721	7	6047	78154	7	6107	78583	7	6167	79007	7	6227	79428	7
5808	76403	7	5868	76849	7	5928	77291	7	5988	77728	7	6048	78161	7	6108	78590	7	6168	79014	7	6228	79435	7
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5810	76418	7	5870	76864	7	5930	77305	8	5990	77743	7	6050	78176	7	6110	78604	7	6170	79029	7	6230	79449	7
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5812	76433	7	5872	76879	7	5932	77320	7	5992	77757	7	6052	78190	7	6112	78618	7	6172	79043	7	6232	79463	7
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5815	76455	7	5875	76901	7	5935	77342	7	5995	77779	7	6055	78211	8	6115	78640	7	6175	79064	7	6235	79484	7
5816	76462	8	5876	76908	8	5936	77349	8	5996	77786	7	6056	78219	7	6116	78647	7	6176	79071	7	6236	79491	7
5817	76470	7	5877	76916	7	5937	77357	7	5997	77793	8	6057	78226	7	6117	78654	7	6177	79078	7	6237	79498	7
5818	76477	8	5878	76923	7	5938	77364	7	5998	77801	7	6058	78233	7	6118	78661	7	6178	79085	7	6238	79505	6
5819	76485	7	5879	76930	8	5939	77371	8	5999	77808	7	6059	78240	7	6119	78668	7	6179	79092	7	6239	79511	7
5820	76492		5880	76938		5940	77379		6000	77815		6060	78247		6120	78675		6180	79099		6240	79518	

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6241	79525	7	6301	79941	7	6361	80353	6	6421	80760	7	6481	81164	7	6541	81564	7	6601	81961	7	6661	82354	6
6242	79532	7	6302	79948	7	6362	80359	7	6422	80767	7	6482	81171	7	6542	81571	7	6602	81968	6	6662	82360	7
6243	79539	7	6303	79955	7	6363	80366	7	6423	80774	7	6483	81178	6	6543	81578	6	6603	81974	7	6663	82367	6
6244	79546	7	6304	79962	7	6364	80373	7	6424	80781	6	6484	81184	7	6544	81584	7	6604	81981	6	6664	82373	7
6245	79553	7	6305	79969	6	6365	80380	7	6425	80787	7	6485	81191	7	6545	81591	7	6605	81987	7	6665	82380	7
6246	79560	7	6306	79975	7	6366	80387	6	6426	80794	7	6486	81198	6	6546	81598	6	6606	81994	6	6666	82387	6
6247	79567	7	6307	79982	7	6367	80393	7	6427	80801	7	6487	81204	7	6547	81604	7	6607	82000	7	6667	82393	7
6248	79574	7	6308	79989	7	6368	80400	7	6428	80808	6	6488	81211	7	6548	81611	6	6608	82007	7	6668	82400	6
6249	79581	7	6309	79996	7	6369	80407	7	6429	80814	7	6489	81218	6	6549	81617	7	6609	82014	6	6669	82406	7
6250	79588	7	6310	80003	7	6370	80414	7	6430	80821	7	6490	81224	7	6550	81624	7	6610	82020	7	6670	82413	6
6251	79595	7	6311	80010	7	6371	80421	7	6431	80828	7	6491	81231	7	6551	81631	6	6611	82027	6	6671	82419	7
6252	79602	7	6312	80017	7	6372	80428	6	6432	80835	6	6492	81238	7	6552	81637	7	6612	82033	7	6672	82426	6
6253	79609	7	6313	80024	6	6373	80434	7	6433	80841	7	6493	81245	6	6553	81644	7	6613	82040	6	6673	82432	7
6254	79616	7	6314	80030	7	6374	80441	7	6434	80848	7	6494	81251	7	6554	81651	6	6614	82046	7	6674	82439	6
6255	79623	7	6315	80037	7	6375	80448	7	6435	80855	7	6495	81258	7	6555	81657	7	6615	82053	7	6675	82445	7
6256	79630	7	6316	80044	7	6376	80455	7	6436	80862	6	6496	81265	6	6556	81664	7	6616	82060	6	6676	82452	6
6257	79637	7	6317	80051	7	6377	80462	6	6437	80868	7	6497	81271	7	6557	81671	6	6617	82066	7	6677	82458	7
6258	79644	6	6318	80058	7	6378	80468	7	6438	80875	7	6498	81278	7	6558	81677	7	6618	82073	6	6678	82465	6
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6260	79657	7	6320	80072	7	6380	80482	7	6440	80889	6	6500	81291	7	6560	81690	7	6620	82086	6	6680	82478	6
6261	79664	7	6321	80079	6	6381	80489	7	6441	80895	7	6501	81298	7	6561	81697	7	6621	82092	7	6681	82484	7
6262	79671	7	6322	80085	7	6382	80496	6	6442	80902	7	6502	81305	6	6562	81704	6	6622	82099	6	6682	82491	6
6263	79678	7	6323	80092	7	6383	80502	7	6443	80909	7	6503	81311	7	6563	81710	7	6623	82105	7	6683	82497	7
6264	79685	7	6324	80099	7	6384	80509	7	6444	80916	6	6504	81318	7	6564	81717	6	6624	82112	7	6684	82504	6
6265	79692	7	6325	80106	7	6385	80516	7	6445	80922	7	6505	81325	6	6565	81723	7	6625	82119	6	6685	82510	7
6266	79699	7	6326	80113	7	6386	80523	7	6446	80929	7	6506	81331	7	6566	81730	7	6626	82125	7	6686	82517	6
6267	79706	7	6327	80120	7	6387	80530	6	6447	80936	7	6507	81338	7	6567	81737	6	6627	82132	6	6687	82523	7
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6269	79720	7	6329	80134	6	6389	80543	7	6449	80949	7	6509	81351	7	6569	81750	7	6629	82145	6	6689	82536	7
6270	79727	7	6330	80140	7	6390	80550	7	6450	80956	7	6510	81358	7	6570	81757	6	6630	82151	7	6690	82543	6
6271	79734	7	6331	80147	7	6391	80557	7	6451	80963	6	6511	81365	6	6571	81763	7	6631	82158	6	6691	82549	7
6272	79741	7	6332	80154	7	6392	80564	6	6452	80969	7	6512	81371	7	6572	81770	6	6632	82164	7	6692	82556	6
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6274	79754	7	6334	80168	7	6394	80577	7	6454	80983	7	6514	81385	6	6574	81783	7	6634	82178	6	6694	82569	6
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6278	79782	7	6338	80195	7	6398	80604	7	6458	81010	7	6518	81411	7	6578	71809	7	6638	82204	6	6698	82595	6
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6282	79810	7	6342	80223	6	6402	80632	6	6462	81037	6	6522	81438	7	6582	81836	6	6642	82230	6	6702	82620	7
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6287	79844	7	6347	80257	7	6407	80665	7	6467	81070	7	6527	81471	7	6587	81869	6	6647	82263	6	6707	82653	6
6288	79851	7	6348	80264	7	6408	80672	7	6468	81077	7	6528	81478	7	6588	81875	7	6648	82269	7	6708	82659	7
6289	79858	7	6349	80271	6	6409	80679	7	6469	81084	6	6529	81485	6	6589	81882	7	6649	81276	6	6709	82666	6
6290	79865	7	6350	80277	7	6410	80686	7	6470	81090	7	6530	81491	7	6590	81889	6	6650	82282	7	6710	82672	7
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6294	79893	7	6354	80305	7	6414	80713	7	6474	81117	7	6534	81518	7	6594	81915	6	6654	82308	7	6714	82698	7
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6296	79906	7	6356	80318	7	6416	80726	7	6476	81131	6	6536	81531	7	6596	81928	7	6656	82321	7	6716	82711	7
6297	79913	7	6357	80325	7	6417	80733	7	6477	81137	7	6537	81538	6	6597	81935	6	6657	82328	6	6717	82718	6
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6299	79927	7	6359	80339	7	6419	80747	7	6479	81151	7	6539	81551	7	6599	81948	6	6659	82341	6	6719	82730	7
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6721	82743	6	6781	83129	6	6841	83512	6	6901	83891	6	6961	84267	6	7021	84640	6	7081	85009	6	7141	85376	6
6722	82750	7	6782	83136	7	6842	83518	6	6902	83897	6	6962	84273	6	7022	84646	6	7082	85016	7	7142	85382	6
6723	82756	6	6783	83142	6	6843	83525	7	6903	83904	7	6963	84280	7	7023	84652	6	7083	85022	6	7143	85388	6
6724	82763	7	6784	83149	7	6844	83531	6	6904	83910	6	6964	84286	6	7024	84658	6	7084	85028	6	7144	85394	6
6725	82769	6	6785	83155	6	6845	83537	6	6905	83916	6	6965	84292	6	7025	84665	7	7085	85034	6	7145	85400	6
6726	82776	7	6786	83161	6	6846	83544	7	6906	83923	7	6966	84298	6	7026	84671	6	7086	85040	6	7146	85406	6
6727	82782	6	6787	83168	7	6847	83550	6	6907	83929	6	6967	84305	7	7027	84677	6	7087	85046	6	7147	85412	6
6728	82789	7	6788	83174	6	6848	83556	6	6908	83935	6	6968	84311	6	7028	84683	6	7088	85052	6	7148	85418	6
6729	82795	6	6789	83181	7	6849	83563	7	6909	83942	7	6969	84317	6	7029	84689	6	7089	85058	6	7149	85425	7
6730	82802	7	6790	83187	6	6850	83569	6	6910	83948	6	6970	84323	6	7030	84696	7	7090	85065	7	7150	85431	6
6731	82808	6	6791	83193	6	6851	83575	6	6911	83954	6	6971	84330	7	7031	84702	6	7091	85071	6	7151	85437	6
6732	82814	6	6792	83200	7	6852	83582	7	6912	83960	6	6972	84336	6	7032	84708	6	7092	85077	6	7152	85443	6
6733	82821	7	6793	83206	6	6853	83588	6	6913	83967	7	6973	84342	6	7033	84714	6	7093	85083	6	7153	85449	6
6734	82827	6	6794	83213	7	6854	83594	6	6914	83973	6	6974	84348	6	7034	84720	6	7094	85089	6	7154	85455	6
6735	82834	7	6795	83219	6	6855	83601	7	6915	83979	6	6975	84354	6	7035	84726	6	7095	85095	6	7155	85461	6
6736	82840	6	6796	83225	6	6856	83607	6	6916	83985	6	6976	84361	7	7036	84733	7	7096	85101	6	7156	85467	6
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6738	82853	6	6798	83238	6	6858	83620	7	6918	83998	6	6978	84373	6	7038	84745	6	7098	85114	7	7158	85479	6
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6740	82866	6	6800	83251	6	6860	83632	6	6920	84011	7	6980	84386	7	7040	84757	6	7100	85126	6	7160	85491	6
6741	82872	6	6801	83257	6	6861	83639	7	6921	84017	6	6981	84392	6	7041	84763	6	7101	85132	6	7161	85497	6
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6743	82885	6	6803	83270	6	6863	83651	6	6923	84029	6	6983	84404	6	7043	84776	6	7103	85144	6	7163	85509	6
6744	82892	7	6804	83276	6	6864	83658	7	6924	84036	7	6984	84410	6	7044	84782	6	7104	85150	6	7164	85516	7
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6746	82905	7	6806	83289	6	6866	83670	6	6926	84048	6	6986	84423	6	7046	84794	6	7106	85163	7	7166	85528	6
6747	82911	6	6807	83296	7	6867	83677	7	6927	84055	7	6987	84429	6	7047	84800	6	7107	85169	6	7167	85534	6
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6752	82943	6	6812	83327	6	6872	83708	6	6932	84086	6	6992	84460	6	7052	84831	6	7112	85199	6	7172	85564	6
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6754	82956	6	6814	83340	6	6874	83721	6	6934	84098	6	6994	84473	7	7054	84844	7	7114	85211	6	7174	85576	6
6755	82963	7	6815	83347	7	6875	83727	6	6935	84105	7	6995	84479	6	7055	84850	6	7115	85217	6	7175	85582	6
6756	82969	6	6816	83353	6	6876	83734	7	6936	84111	6	6996	84485	6	7056	84856	6	7116	85224	7	7176	85588	6
6757	82975	6	6817	83359	6	6877	83740	6	6937	84117	6	6997	84491	6	7057	84862	6	7117	85230	6	7177	85594	6
6758	82982	7	6818	83366	7	6878	83746	6	6938	84123	6	6998	84497	6	7058	84868	6	7118	85236	6	7178	85600	6
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6760	82995	7	6820	83378	6	6880	83759	6	6940	84136	6	7000	84510	6	7060	84880	6	7120	85248	6	7180	85612	6
6761	83001	6	6821	83385	7	6881	83765	6	6941	84142	6	7001	84516	6	7061	84887	7	7121	85254	6	7181	85618	6
6762	83008	7	6822	83391	6	6882	83771	6	6942	84148	6	7002	84522	6	7062	84893	6	7122	85260	6	7182	85625	7
6763	83014	6	6823	83398	7	6883	83778	7	6943	84155	7	7003	84528	6	7063	84899	6	7123	85266	6	7183	85631	6
6764	83020	6	6824	83404	6	6884	83784	6	6944	84161	6	7004	84535	7	7064	84905	6	7124	85272	6	7184	85637	6
6765	83027	7	6825	83410	6	6885	83790	6	6945	84167	6	7005	84541	6	7065	84911	6	7125	85278	6	7185	85643	6
6766	83033	6	6826	83417	7	6886	83797	7	6946	84173	6	7006	84547	6	7066	84917	6	7126	85285	7	7186	85649	6
6767	83040	7	6827	83423	6	6887	83803	6	6947	84180	7	7007	84553	6	7067	84924	7	7127	85291	6	7187	85655	6
6768	83046	6	6828	83429	6	6888	83809	6	6948	84186	6	7008	84559	6	7068	84930	6	7128	85297	6	7188	85661	6
6769	83052	6	6829	83436	7	6889	83816	7	6949	84192	6	7009	84566	7	7069	84936	6	7129	85303	6	7189	85667	6
6770	83059	7	6830	83442	6	6890	83822	6	6950	84198	6	7010	84572	6	7070	84942	6	7130	85309	6	7190	85673	6
6771	83065	6	6831	83448	6	6891	83828	6	6951	84205	7	7011	84578	6	7071	84948	6	7131	85315	6	7191	85679	6
6772	83072	7	6832	83455	7	6892	83835	7	6952	84211	6	7012	84584	6	7072	84954	6	7132	85321	6	7192	85685	6
6773	83078	6	6833	83461	6	6893	83841	6	6953	84217	6	7013	84590	6	7073	84960	6	7133	85327	6	7193	85691	6
6774	83085	7	6834	83467	6	6894	83847	6	6954	84223	6	7014	84597	7	7074	84967	7	7134	85333	6	7194	85697	6
6775	83091	6	6835	83474	7	6895	83853	6	6955	84230	7	7015	84603	6	7075	84973	6	7135	85339	6	7195	85703	6
6776	83097	6	6836	83480	6	6896	83860	7	6956	84236	6	7016	84609	6	7076	84979	6	7136	85345	6	7196	85709	6
6777	83104	7	6837	83487	7	6897	83866	6	6957	84242	6	7017	84615	6	7077	84985	6	7137	85352	7	7197	85715	6
6778	83110	6	6838	83493	6	6898	83872	6	6958	84248	6	7018	84621	6	7078	84991	6	7138	85358	6	7198	85721	6
6779	83117	7	6839	83499	6	6899	83879	7	6959	84255	7	7019	84628	7	7079	84997	6	7139	85364	6	7199	85727	6
6780	83123	6	6840	83506	7	6900	83885	6	6960	84261	6	7020	84634	6	7080	85003	6	7140	85370	6	7200	85733	6

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7202	85745	6	7262	86106	6	7322	86463	6	7382	86817	6	7442	87169	6	7502	87512	5	7562	87864	5	7622	88207	6
7203	85751	6	7263	86112	6	7323	86469	6	7383	86823	6	7443	87175	6	7503	87523	6	7563	87869	6	7623	88213	5
7204	85757	6	7264	86118	6	7324	86475	6	7384	86829	6	7444	87181	5	7504	87529	6	7564	87875	6	7624	88218	6
7205	85763	6	7265	86124	6	7325	86481	6	7385	86835	6	7445	87186	6	7505	87535	6	7565	87881	6	7825	88224	6
7206	85769	6	7266	86130	6	7326	86487	6	7386	86841	6	7446	87192	6	7506	87541	6	7566	87887	5	7626	88230	5
7207	85775	6	7267	86136	5	7327	86493	6	7387	86847	6	7447	87198	6	7507	87547	5	7567	87892	6	7627	88235	6
7208	85781	7	7268	86141	6	7328	86499	5	7388	86853	6	7448	87204	6	7508	87552	6	7568	87898	6	7628	88241	6
7209	85788	6	7269	86147	6	7329	86504	6	7389	86859	5	7449	87210	6	7509	87558	6	7569	87904	6	7629	88247	5
7210	85794	6	7270	86153	6	7330	86510	6	7390	86864	6	7450	87216	5	7510	87564	6	7570	87910	5	7630	88252	6
7211	85800	6	7271	86159	6	7331	86516	6	7391	86870	6	7451	87221	6	7511	87570	6	7571	87915	6	7631	88258	6
7212	85806	6	7272	86165	6	7332	86522	6	7392	86876	6	7452	87227	6	7512	87576	5	7572	87921	6	7632	88264	6
7213	85812	6	7273	86171	6	7333	86528	6	7393	86882	6	7453	87233	6	7513	87581	6	7573	87927	6	7633	88270	5
7214	85818	6	7274	86177	6	7334	86534	6	7394	86888	6	7454	87239	6	7514	87587	6	7574	87933	5	7634	88275	6
7215	85824	6	7275	86183	6	7335	86540	6	7395	86894	6	7455	87245	6	7515	87593	6	7575	87938	6	7635	88281	6
7216	85830	6	7276	86189	6	7336	86546	6	7396	86900	6	7456	87251	5	7516	87599	5	7576	87944	6	7636	88287	5
7217	85836	6	7277	86195	6	7337	86552	6	7397	86906	5	7457	87256	6	7517	87604	6	7577	87950	5	7637	88292	6
7218	85842	6	7278	86201	6	7338	86558	6	7398	86911	6	7458	87262	6	7518	87610	6	7578	87955	6	7638	88298	6
7219	85848	6	7279	86207	6	7339	86564	6	7399	86917	6	7459	87268	6	7519	87616	6	7579	87961	6	7639	88304	5
7220	85854	6	7280	86213	6	7340	86570	6	7400	86923	6	7460	87274	6	7520	87622	6	7580	87967	6	7640	88309	6
7221	85860	6	7281	86219	6	7341	86576	5	7401	86929	6	7461	87280	6	7521	87628	5	7581	87973	5	7641	88315	6
7222	85866	6	7282	86225	6	7342	86581	6	7402	86935	6	7462	87286	5	7522	87633	6	7582	87978	6	7642	88321	5
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7224	85878	6	7284	86237	6	7344	86593	6	7404	86947	6	7464	87297	6	7524	87645	6	7584	87990	6	7644	88332	6
7225	85884	6	7285	86243	6	7345	86599	6	7405	86953	5	7465	87303	6	7525	87651	5	7585	87996	5	7645	88338	5
7226	85890	6	7286	86249	6	7346	86605	6	7406	86958	6	7466	87309	6	7526	87656	6	7586	88001	6	7646	88343	6
7227	85896	6	7287	86255	6	7347	86611	6	7407	86964	6	7467	87315	5	7527	87662	6	7587	88007	6	7647	88349	6
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7231	85920	6	7291	86279	6	7351	86635	6	7411	86988	6	7471	87338	6	7531	87685	6	7591	88030	6	7651	88372	5
7232	85926	6	7292	86285	6	7352	86641	5	7412	86994	5	7472	87344	5	7532	87691	6	7592	88036	5	7652	88377	6
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7234	85938	6	7294	86297	6	7354	86652	6	7414	87005	6	7474	87355	6	7534	87703	5	7594	88047	6	7654	88389	6
7235	85944	6	7295	86303	5	7355	86658	6	7415	87011	6	7475	87361	6	7535	87708	6	7595	88053	5	7655	88395	5
7236	85950	6	7296	86308	6	7356	86664	6	7416	87017	6	7476	87367	6	7536	87714	6	7596	88058	6	7656	88400	6
7237	85956	6	7297	86314	6	7357	86670	6	7417	87023	6	7477	87373	6	7537	87720	6	7597	88064	6	7657	88406	6
7238	85962	6	7298	86320	6	7358	86676	6	7418	87029	6	7478	87379	5	7538	87726	5	7598	88070	6	7658	88412	5
7239	85968	6	7299	86326	6	7359	86682	6	7419	87035	5	7479	87384	6	7539	87731	6	7599	88076	5	7659	88417	6
7240	85974	6	7300	86332	6	7360	86688	6	7420	87040	6	7480	87390	6	7540	87737	6	7600	88081	6	7660	88423	6
7241	85980	6	7301	86338	6	7361	86694	6	7421	87046	6	7481	87396	6	7541	87743	6	7601	88087	6	7661	88429	5
7242	85986	6	7302	86344	6	7362	86700	5	7422	87052	6	7482	87402	6	7542	87749	5	7602	88093	5	7662	88434	6
7243	85992	6	7303	86350	6	7363	86705	6	7423	87058	6	7483	87408	5	7543	87754	6	7603	88098	6	7663	88440	6
7244	85998	6	7304	86356	6	7364	86711	6	7424	87064	6	7484	87413	6	7544	87760	6	7604	88104	6	7664	88446	5
7245	86004	6	7305	86362	6	7365	86717	6	7425	87070	5	7485	87419	6	7545	87766	6	7605	88110	6	7665	88451	6
7246	86010	6	7306	86368	6	7366	86723	6	7426	87075	6	7486	87425	6	7546	87772	5	7606	88116	5	7666	88457	6
7247	86016	6	7307	86374	6	7367	86729	6	7427	87081	6	7487	87431	6	7547	87777	6	7607	88121	6	7667	88463	5
7248	86022	6	7308	86380	6	7368	86735	6	7428	87087	6	7488	87437	5	7548	87783	6	7608	88127	6	7668	88468	6
7249	86028	6	7309	86386	6	7369	86741	6	7429	87093	6	7489	87442	6	7549	87789	6	7609	88133	5	7669	88474	6
7250	86034	6	7310	86392	6	7370	86747	6	7430	87099	6	7490	87448	6	7550	87795	5	7610	88138	6	7670	88480	5
7251	86040	6	7311	86398	6	7371	86753	6	7431	87105	6	7491	87454	6	7551	87800	6	7611	88144	6	7671	88485	6
7252	86046	6	7312	86404	6	7372	86759	5	7432	87111	5	7492	87460	6	7552	87806	6	7612	88150	6	7672	88491	6
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7254	86058	6	7314	86415	6	7374	8677	6	7434	87122	6	7494	87471	6	7554	87818	5	7614	88161	6	7674	88502	6
7255	86064	6	7315	86421	6	7375	86776	6	7435	87128	6	7495	87477	6	7555	87823	6	7615	88167	6	7675	88508	5
7256	86070	6	7316	86427	6	7376	86782	6	7436	87134	6	7496	87483	6	7556	87829	6	7616	88173	5	7676	88513	6
7257	86076	6	7317	86433	6	7377	86788	6	7437	87140	6	7497	87489	6	7557	87835	6	7617	88178	6	7677	88519	6
7258	86082	6	7318	86439	6	7378	86794	6	7438	87146	5	7498	87495	5	7558	87841	5	7618	88184	6	7678	88525	5
7259	86088	6	7319	86445	6	7379	86800	6	7439	87151	6	7499	87500	6	7559	87846	6	7619	88190	6	7679	88530	6
7260	86094		7320	86451		7380	86806		7440	87157		7500	87506		7560	87852		7620	88195		7680	88536	

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7681	88542	5	7741	88880	5	7801	89215	6	7861	89548	5	7921	89878	5	7981	90206	5	8041	90531	5	8101	90854	5
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7683	88553	6	7743	88891	6	7803	89226	6	7863	89559	5	7923	89889	5	7983	90217	5	8043	90542	5	8103	90865	5
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LOGARITHMS OF NUMBERS.

N.	Log.	D.	N.	Log.	D	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log	D.	N.	Log.	D
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8166	91201	5	8226	91519	5	8286	91834	6	8346	92148	5	8406	92459	5	8466	92768	5	8526	93075	5	8586	93379	5
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8169	91217	5	8229	91535	5	8289	91850	5	8349	92163	6	8409	92474	6	8469	92783	5	8529	83090	5	8589	93394	5
8170	91222	6	8230	91540	5	8290	91855	6	8350	92169	5	8410	92480	5	8470	92788	5	8530	93095	5	8590	93399	5
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8218	91477	5	8278	91793	5	8338	92106	5	8398	92418	5	8458	92727	5	8518	93034	5	8578	93339	5	8638	93641	5
8219	91482	5	8279	91798	5	8339	92111	6	8399	92423	5	8459	92732	5	8519	93039	5	8579	93344	5	8639	93646	5
8220	91487		8280	91803		8340	92117		8400	92428		8460	92737		8520	93044		8580	93349		8640	93651	

LOGARITHMS OF NUMBERS.

N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.
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8641	93656	5	8701	93957	5	8761	94255	5	8821	94552	5	8881	94846	5	8941	95139	4	9001	95429	5	9061	95718	4
8642	93661	5	8702	93962	5	8762	94260	5	8822	94557	5	8882	94851	5	8942	95143	5	9002	95434	5	9062	95722	5
8643	93666	5	8703	93967	5	8763	94265	5	8823	94562	5	8883	94856	5	8943	95148	5	9003	95436	5	9063	95727	5
8644	93671	5	8704	93972	5	8764	94270	5	8824	94567	4	8884	94861	5	8944	95153	5	9004	95444	4	9064	95732	5
8645	93676	6	8705	93977	5	8765	94275	5	8825	94571	5	8885	94866	5	8945	95158	5	9005	95448	5	9065	95737	5
8646	93682	5	8706	93982	5	8766	94280	5	8826	94576	5	8886	94871	5	8946	95163	5	9006	95453	5	9066	95742	4
8647	93687	5	8707	93987	5	8767	94285	5	8827	94581	5	8887	94876	4	8947	95168	5	9007	95458	5	9067	95746	5
8648	93692	5	8708	93992	5	8768	94290	5	8828	94586	5	8888	94880	5	8948	95173	4	9008	95463	5	9068	95751	5
8649	93697	5	8709	93997	5	8769	94295	5	8829	94591	5	8889	94885	5	8949	95177	5	9009	95468	4	9069	95756	5
8650	93702	5	8710	94002	5	8770	94300	5	8830	94596	5	8890	94890	5	8950	95182	5	9010	95472	5	9070	95761	5
8651	93707	5	8711	94007	5	8771	94305	5	8831	94601	5	8891	94895	5	8951	95187	5	9011	95477	5	9071	95766	4
8652	93712	5	8712	94012	5	8772	94310	5	8832	94606	5	8892	94900	5	8952	95192	5	9012	95482	5	9072	95770	5
8653	93717	5	8713	94017	5	8773	94315	5	8833	94611	5	8893	94905	5	8953	95197	5	9013	95487	5	9073	95775	5
8654	93722	5	8714	94022	5	8774	94320	5	8834	94616	5	8894	94910	5	8954	95202	5	9014	95492	5	9074	95780	5
8655	93727	5	8715	94027	5	8775	94325	5	8835	94621	5	8895	94915	4	8955	95207	4	9015	95497	4	9075	95785	4
8656	93732	5	8716	94032	5	8776	94330	5	8836	94626	4	8896	94919	5	8956	95211	5	9016	95501	5	9076	95789	5
8657	93737	5	8717	94037	5	8777	94335	5	8837	94630	5	8897	94924	5	8957	95216	5	9017	95506	5	9077	95794	5
8658	93742	5	8718	94042	5	8778	94340	5	8838	94635	5	8898	94929	5	8958	95221	5	9018	95511	5	9078	95799	5
8659	93747	5	8719	94047	5	8779	94345	4	8839	94640	5	8899	94934	5	8959	95226	5	9019	95516	5	9079	95804	5
8660	93752	5	8720	94052	5	8780	94349	5	8840	94645	5	8900	94939	5	8960	95231	5	9020	95521	4	9080	95809	4
8661	93757	5	8721	94057	5	8781	94354	5	8841	94650	5	8901	94944	5	8961	95236	4	9021	95525	5	9081	95813	5
8662	93762	5	8722	94062	5	8782	94359	5	8842	94655	5	8902	94949	5	8962	95240	5	9022	95530	5	9082	95818	5
8663	93767	5	8723	94067	5	8783	94364	5	8843	94660	5	8903	94954	5	8963	95245	5	9023	95535	5	9083	95823	5
8664	93772	5	8724	94072	5	8784	94369	5	8844	94665	5	8904	94959	4	8964	95250	5	9024	95540	5	9084	95828	4
8665	93777	5	8725	94077	5	8785	94374	5	8845	94670	5	8905	94963	5	8965	95255	5	9025	95545	5	9085	95832	5
8666	93782	5	8726	94082	4	8786	94379	5	8846	94675	5	8906	94968	5	8966	95260	5	9026	95550	4	9086	95837	5
8667	93787	5	8727	94086	5	8787	94384	5	8847	94680	5	8907	94973	5	8967	95265	5	9027	95554	5	9087	95842	5
8668	93792	5	8728	94091	5	8788	94389	5	8848	94685	4	8908	94978	5	8968	95270	4	9028	95559	5	9088	95847	5
8669	93797	5	8729	94096	5	8789	94394	5	8849	94689	5	8909	94983	5	8969	95274	5	9029	95564	5	9089	95852	4
8670	93802	5	8730	94101	5	8790	94399	5	8850	94694	5	8910	94988	5	8970	95279	5	9030	95569	5	9090	95856	5
8671	93807	5	8731	94106	5	8791	94404	5	8851	94699	5	8911	94993	5	8971	95284	5	9031	95574	4	9091	95861	5
8672	93812	5	8732	94111	5	8792	94409	5	8852	94704	5	8912	94998	4	8972	95289	5	9032	95578	5	9092	95866	5
8673	93817	5	8733	94116	5	8793	94414	5	8853	94709	5	8913	95002	5	8973	95294	5	9033	95583	5	9093	95871	4
8674	93822	5	8734	94121	5	8794	94419	5	8854	94714	5	8914	95007	5	8974	95299	4	9034	95588	5	9094	95875	5
8675	93827	5	8735	94126	5	8795	94424	5	8855	94719	5	8915	95012	5	8975	95303	5	9035	95593	5	9095	95880	5
8676	93832	5	8736	94131	5	8796	94429	4	8856	94724	5	8916	95017	5	8976	95308	5	9036	95598	4	9096	95885	5
8677	93837	5	8737	94136	5	8797	94433	5	8857	94729	5	8917	95022	5	8977	95313	5	9037	95602	5	9097	95890	5
8678	93842	5	8738	94141	5	8798	94438	5	8858	94734	4	8918	95027	5	8978	95318	5	9038	95607	5	9098	95895	4
8679	93847	5	8739	94146	5	8799	94443	5	8859	94738	5	8919	95032	4	8979	95323	5	9039	95612	5	9099	95899	5
8680	93852	5	8740	94151	5	8800	94448	5	8860	94743	5	8920	95036	5	8980	95328	4	9040	95617	5	9100	95904	5
8681	93857	5	8741	94156	5	8801	94453	5	8861	94748	5	8921	95041	5	8981	95332	5	9041	95622	4	9101	95909	5
8682	93862	5	8742	94161	5	8802	94458	5	8862	94753	5	8922	95046	5	8982	95337	5	9042	95626	5	9102	95914	4
8683	93867	5	8743	94166	5	8803	94463	5	8863	94758	5	8923	95051	5	8983	95342	5	9043	95631	5	9103	95918	5
8684	93872	5	8744	94171	5	8804	94468	5	8864	94763	5	8924	95056	5	8984	95347	5	9044	95636	5	9104	95923	5
8685	93877	5	8745	94176	5	8805	94473	5	8865	94768	5	8925	95061	5	8985	95352	5	9045	95641	5	9105	95928	5
8686	93882	5	8746	94181	5	8806	94478	5	8866	94773	5	8926	95066	5	8986	95357	4	9046	95646	4	9106	95933	5
8687	93887	5	8747	94186	5	8807	94483	5	8867	94778	5	8927	95071	4	8987	95361	5	9047	95650	5	9107	95938	4
8688	93892	5	8748	94191	5	8808	94488	5	8868	94783	4	8928	95075	5	8988	95366	5	9048	95655	5	9108	95942	5
8689	93897	5	8749	94196	5	8809	94493	5	8869	94787	5	8929	95080	5	8989	95371	5	9049	95660	5	9109	95947	5
8690	93902	5	8750	94201	5	8810	94498	5	8870	94792	5	8930	95085	5	8990	95376	5	9050	95665	5	9110	95952	5
8691	93907	5	8751	94206	5	8811	94503	4	8871	94797	5	8931	95090	5	8991	95381	5	9051	95670	4	9111	95957	4
8692	93912	5	8752	94211	5	8812	94507	5	8872	94802	5	8932	95095	5	8992	95386	4	9052	95674	5	9112	95961	5
8693	93917	5	8753	94216	5	8813	94512	5	8873	94807	5	8933	95100	5	8993	95390	5	9053	95679	5	9113	95966	5
8694	93822	5	8754	94221	5	8814	94517	5	8874	94812	5	8934	95105	4	8994	95395	5	9054	95684	5	9114	95971	5
8695	93927	5	8755	94226	5	8815	94522	5	8875	94817	5	8935	95109	5	8995	95400	5	9055	95689	5	9115	95976	4
8696	93932	5	8756	94231	5	8816	94527	5	8876	94822	5	8936	95114	5	8996	95405	5	9056	95694	4	9116	95980	5
8697	93937	5	8757	94236	4	8817	94532	5	8877	94827	5	8937	95119	5	8997	95410	5	9057	95698	5	9117	95985	5
8698	93942	5	8758	94240	5	8818	94537	5	8878	94832	4	8938	95124	5	8998	95415	4	9058	95703	5	9118	95990	5
8699	93947	5	8759	94245	5	8819	94542	5	8879	94836	5	8939	95129	5	8999	95419	5	9059	95708	5	9119	95995	4
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LOGARITHMS OF NUMBERS.

N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D	N.	Log	D.	N.	Log.	D.
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9121	96004	5	9181	96289	5	9241	96572	5	9301	96853	5	9361	97132	4	9421	97410	5	9481	97685	4	9541	97959	4
9122	96009	5	9182	96294	5	9242	96577	5	9302	96858	5	9362	97137	5	9422	97414	4	9482	97690	5	9542	97964	5
9123	96014	5	9183	96298	4	9243	96581	4	9303	96862	4	9363	97142	5	9423	97419	5	9483	97695	5	9543	97968	4
9124	96019	5	9184	96303	5	9244	96586	5	9304	96867	5	9364	97146	4	9424	97424	5	9484	97699	4	9544	97973	5
9125	96023	4	9185	96308	5	9245	96591	5	9305	96872	5	9365	97151	5	9425	97428	4	9485	97704	5	9545	97978	5
9126	96028	5	9186	96313	5	9246	96595	4	9306	96876	4	9366	97155	4	9426	97433	5	9486	97708	4	9546	97982	4
9127	96033	5	9187	96317	4	9247	96600	5	9307	96881	5	9367	97160	5	9427	97437	4	9487	97713	5	9547	97986	5
9128	96038	5	9188	96322	5	9248	96605	5	9308	96886	5	9368	97165	5	9428	97442	5	9488	97717	4	9548	97991	4
9129	96042	4	9189	96327	5	9249	96609	4	9309	96890	4	9369	97169	4	9429	97447	5	9489	97722	5	9549	97996	5
9130	96047	5	9190	96332	5	9250	96614	5	9310	96895	5	9370	97174	5	9430	97451	4	9490	97727	5	9550	98000	4
9131	96052	5	9191	96336	4	9251	96619	5	9311	96900	5	9371	97179	5	9431	97456	5	9491	97731	4	9551	98005	5
9132	96057	5	9192	96341	5	9252	96624	5	9312	96904	4	9372	97183	4	9432	97460	4	9492	97736	5	9552	98009	4
9133	96061	4	9193	96346	5	9253	96628	4	9313	96909	5	9373	97188	5	9433	97465	5	9493	97740	4	9553	98014	5
9134	96066	5	9194	96350	4	9254	96633	5	9314	96914	5	9374	97192	4	9434	97470	5	9494	97745	5	9554	98019	5
9135	96071	5	9195	96355	5	9255	96638	5	9315	96918	4	9375	97197	5	9435	97474	4	9495	97749	4	9555	98023	4
9136	96076	5	9196	96360	5	9256	96642	4	9316	96923	5	9376	97202	5	9436	97479	5	9496	97754	5	9556	98028	5
9137	96080	4	9197	96365	5	9257	96647	5	9317	96928	5	9377	97206	4	9437	97483	4	9497	97759	5	9557	98032	4
9138	96085	5	9198	96369	4	9258	96652	5	9318	96932	4	9378	97211	5	9438	97488	5	9498	97763	4	9558	98037	5
9139	96090	5	9199	96374	5	9259	96656	4	9319	96937	5	9379	97216	5	9439	97493	5	9499	97768	5	9559	98041	4
9140	96095	5	9200	96379	5	9260	96661	5	9320	96942	5	9380	97220	4	9440	97497	4	9500	97772	4	9560	98046	5
9141	96099	4	9201	96384	5	9261	96666	5	9321	96946	4	9381	97225	5	9441	97502	5	9501	97777	5	9561	98050	4
9142	96104	5	9202	96388	4	9262	96670	4	9322	96951	5	9382	97230	5	9442	97506	4	9502	97782	5	9562	98055	5
9143	96109	5	9203	96393	5	9263	96675	5	9323	96956	5	9383	97234	4	9443	97511	5	9503	97786	4	9563	98059	4
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9145	96118	4	9205	96402	4	9265	96685	5	9325	96965	5	9385	97243	4	9445	97520	4	9505	97795	4	9565	98068	4
9146	96123	5	9206	96407	5	9266	96689	4	9326	96970	5	9386	97248	5	9446	97525	5	9506	97800	5	9566	98073	5
9147	96128	5	9207	96412	5	9267	96694	5	9327	96974	4	9387	97253	5	9447	97529	4	9507	97804	4	9567	98078	5
9148	96133	5	9208	96417	5	9268	96699	5	9328	96979	5	9388	97257	4	9448	97534	5	9508	97809	5	9568	98082	4
9149	96137	4	9209	96421	4	9269	96703	4	9329	96984	5	9389	97262	5	9449	97539	5	9509	97813	4	9569	98087	5
9150	96142	5	9210	96426	5	9270	96708	5	9330	96988	4	9390	97267	5	9450	97543	4	9510	97818	5	9570	98091	4
9151	96147	5	9211	96431	5	9271	96713	5	9331	96993	5	9391	97271	4	9451	97548	5	9511	97823	5	9571	98096	5
9152	96152	5	9212	96435	4	9272	96717	4	9332	96997	4	9392	97276	5	9452	97552	4	9512	97827	4	9572	98100	4
9153	96156	4	9213	96440	5	9273	96722	5	9333	97002	5	9393	97281	5	9453	97557	5	9513	97832	5	9573	98105	5
9154	96161	5	9214	96445	5	9274	96727	5	9334	97007	5	9394	97285	4	9454	97562	5	9514	97836	4	9574	98109	4
9155	96166	5	9215	96450	5	9275	96731	4	9335	97011	4	9395	97290	5	9455	97566	4	9515	97841	5	9575	98114	5
9156	96171	5	9216	96454	4	9276	96736	5	9336	97016	5	9396	97294	4	9456	97571	5	9516	97845	4	9576	98118	4
9157	96175	4	9217	96459	5	9277	96741	5	9337	97021	5	9397	97299	5	9457	97575	4	9517	97850	5	9577	98123	5
9158	96180	5	9218	96464	5	9278	96745	4	9338	97025	4	9398	97304	5	9458	97580	5	9518	97855	5	9578	98127	4
9159	96185	5	9219	96468	4	9279	96750	5	9339	97030	5	9399	97308	4	9459	97585	5	9519	97859	4	9579	98132	5
9160	96190	5	9220	96473	5	9280	96755	5	9340	97035	5	9400	97313	5	9460	97589	4	9520	97864	5	9580	98137	5
9161	96194	4	9221	96478	5	9281	96759	4	9341	97039	4	9401	97317	4	9461	97594	5	9521	97868	4	9581	98141	4
9162	96199	5	9222	96483	5	9282	96764	5	9342	97044	5	9402	97322	5	9462	97598	4	9522	97873	5	9582	98146	5
9163	96204	5	9223	96487	4	9283	96769	5	9343	97049	5	9403	97327	5	9463	97603	5	9523	97877	4	9583	98150	4
9164	96209	5	9224	96492	5	9284	96774	5	9344	97053	4	9404	97331	4	9464	97607	4	9524	97882	5	9584	98155	5
9165	96213	4	9225	96497	5	9285	96778	4	9345	97058	5	9405	97336	5	9465	97612	5	9525	97886	4	9585	98159	4
9166	96218	5	9226	96501	4	9286	96783	5	9346	97063	5	9406	97340	4	9466	97617	5	9526	97891	5	9586	98164	5
9157	96223	5	9227	96596	5	9287	96788	5	9347	97067	4	9407	97345	5	9467	97621	4	9527	97896	5	9587	98168	4
9168	96227	4	9228	96511	5	9288	96792	4	9348	97072	5	9408	97350	5	9468	97626	5	9528	97900	4	9588	98173	5
9169	96232	5	9229	96515	4	9289	96797	5	9349	97077	5	9409	97354	4	9469	97630	4	9529	97905	5	9589	98177	4
9170	96237	5	9230	96520	5	9290	96802	5	9350	97081	4	9410	97359	5	9470	97685	5	9530	97909	4	9590	98182	5
9171	97242	5	9231	96525	5	9291	96806	4	9351	97086	5	9411	97364	5	9471	97640	5	9531	97914	5	9591	98186	4
9172	96246	4	9232	96530	5	9292	96811	5	9352	97090	4	9412	97368	4	9472	97644	4	9532	97918	4	9592	98191	5
9173	96251	5	9233	96534	4	9293	96816	5	9353	97095	5	9413	97373	5	9473	97649	5	9533	97923	5	9593	98195	4
9174	96256	5	9234	96539	5	9294	96820	4	9354	97100	5	9414	97377	4	9474	97653	4	9534	97928	5	9594	98200	5
9175	96261	5	9235	96544	5	9295	96825	5	9355	97104	4	9415	97382	5	9475	97658	5	9535	97932	4	9595	98204	4
9176	96265	4	9236	96548	4	9296	96830	5	9356	97109	5	9416	97387	5	9476	97663	5	9536	97937	5	9596	98209	5
9177	96370	5	9237	96553	5	9297	96834	4	9357	97114	5	9417	97391	4	9477	97667	4	9537	97941	4	9597	98214	5
9178	96275	5	9238	96558	5	9298	96839	5	9358	97118	4	9418	97396	5	9478	97672	5	9538	97946	5	9598	98218	4
9179	96280	5	9239	96562	4	9299	96844	5	9359	97123	5	9419	97400	4	9479	97676	4	9539	97950	4	9599	98223	5
9180	96284	4	9240	96567	5	9300	96848	4	9360	97128	5	9420	97440	5	9480	97681	5	9540	97955	5	9600	98227	4

LOGARITHMIS OF NUMBERS.

N.	Log.	D.	N	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D.	N.	Log.	D	N.	Log	D.	N.	Log.	D.
9600	98227	5	9650	98453	4	9700	98677	5	9750	98900	5	9800	99123	4	9850	99344	4	9900	99564	4	9950	99782	5
9601	98232	4	9651	98457	5	9701	98682	4	9751	98905	4	9801	99127	4	9851	99348	4	9901	99568	4	9951	99787	4
9602	98236	5	9652	98462	4	9702	98686	5	9752	98909	5	9802	99131	5	9852	99352	5	9902	99572	5	9952	99791	4
9603	98241	4	9653	98466	5	9703	98691	4	9753	98914	4	9803	99136	4	9853	99357	4	9903	99577	4	9953	99795	5
9604	98245	5	9654	98471	4	9704	98695	5	9754	98918	5	9804	99140	5	9854	99361	5	9904	99581	4	9954	99800	4
9605	98250	4	9655	98475	5	9705	98700	4	9755	98923	4	9805	99145	4	9855	99366	4	9905	99585	5	9955	99804	4
9606	98254	5	9656	98480	4	9706	98704	5	9756	98927	5	9806	99149	5	9856	99370	4	9906	99590	4	9956	99808	5
9607	98259	4	9657	98484	5	9707	98709	4	9757	98932	4	9807	99154	4	9857	99374	5	9907	99594	5	9957	99813	4
9608	98263	5	9658	98489	4	9808	98713	4	9758	98936	5	9808	99158	4	9858	99379	4	9908	99599	4	9958	99817	5
9609	98268	4	9659	98493	5	9709	98717	5	9759	98941	4	9809	99162	5	9859	99383	5	9909	99603	4	9959	99822	4
9610	98272	5	9660	98498	4	9710	98722	4	9760	98945	4	9810	99167	4	9860	99388	4	9910	99607	5	9960	99826	4
9611	98277	4	9661	98502	5	9711	98726	5	9761	98949	5	9811	99171	5	9861	99392	4	9911	99612	4	9961	99830	5
9612	98281	5	9662	98507	4	9712	98731	4	9762	98954	4	9812	99176	4	9862	99396	5	9912	99616	5	9962	99835	4
9613	98286	4	9663	98511	5	9713	98735	5	9763	98958	5	9813	99180	5	9863	99401	4	9913	99621	4	9963	99839	4
9614	98290	5	9664	98516	4	9714	98740	4	9764	98963	4	9814	99185	4	9864	99405	5	9914	99625	4	9964	99843	5
9615	98295	4	9665	98520	5	9715	98744	5	9765	98967	5	9815	99189	4	9865	99410	4	9915	99629	5	9965	99848	4
9616	98299	5	9666	98525	4	9716	98749	4	9766	98972	4	9816	99193	5	9866	99414	5	9916	99634	4	9966	99852	4
9617	98304	4	9667	98529	5	9717	98753	5	9767	98976	5	9817	99198	4	9867	99419	4	9917	99638	4	9967	99856	5
9618	98308	5	9668	98534	4	9718	98758	4	9768	98981	4	9818	99202	5	9868	99423	4	9918	99642	5	9968	99861	4
9619	98313	5	9669	98538	5	9719	98762	5	9769	98985	4	9819	99207	4	9869	99427	5	9919	99647	4	9969	99865	5
9620	98318	4	9670	98543	4	9720	98767	4	9770	98989	5	9820	99211	5	9870	99432	4	9920	99651	5	9970	99870	4
9621	98322	5	9671	98547	5	9721	98771	5	9771	98994	4	9821	99216	4	9871	99436	5	9921	99656	4	9971	99874	4
9622	98327	4	9672	98652	4	9722	98776	4	9772	98998	5	9822	99220	4	9872	99441	4	9922	99660	4	9972	99878	5
9623	98331	5	9673	98551	5	9723	98780	4	9773	99003	4	9823	99224	5	9873	99445	4	9923	99664	5	9973	99883	4
9624	98336	4	9674	98562	4	9724	98784	5	9774	99007	5	9824	99229	4	9874	99449	5	9924	99669	4	9974	99887	4
9625	98340	5	9675	98565	5	9725	98789	4	9775	99012	4	9825	99233	5	9875	99454	4	9925	99673	4	9975	99891	5
9626	98345	4	9676	98570	4	9726	98793	5	9776	99016	5	9826	99238	4	9876	99458	5	9926	99677	5	9976	99896	4
9627	98349	5	9677	98574	5	9727	98798	4	9777	99021	4	9827	99242	5	9877	99463	4	9927	99682	4	9977	99900	4
9628	98354	4	9678	98579	4	9728	98802	5	9778	99025	4	9828	99247	4	9878	99467	4	9928	99686	5	9978	99904	5
9629	98358	5	9679	98583	5	9729	98807	4	9779	99029	5	9829	99251	4	9879	99471	5	9929	99691	4	9979	99909	4
9630	98363	4	9680	98588	4	9730	98811	5	9780	99034	4	9830	99265	5	9880	99476	4	9930	99695	4	9980	99913	4
9631	98367	5	9681	98592	5	9731	98816	4	9781	99038	5	9831	99260	4	9881	99480	4	9931	99699	5	9981	99917	5
9632	98372	4	9682	98597	4	9732	98820	5	9782	99043	4	9832	99264	5	9882	99484	5	9932	99704	4	9982	99922	4
9633	98376	5	9683	98601	4	9733	98825	4	9783	99047	5	9833	99269	4	9883	99489	4	9933	99708	4	9983	99926	4
9634	98381	4	9684	98605	5	9734	98829	5	9784	99052	4	9834	99273	4	9884	99493	5	9934	99712	5	9984	99930	5
9635	98385	5	9685	98610	4	9735	98834	4	9785	99056	5	9835	99277	5	9885	99498	4	9935	99717	4	9985	99935	4
9636	98390	4	9686	98614	5	9736	98838	5	9786	99061	4	9836	99282	4	9886	99502	4	9936	99721	5	9986	99939	5
9637	98394	5	9687	98619	4	9737	98843	4	9787	99065	4	9837	99286	5	9887	99506	5	9937	99726	4	9987	99944	4
9638	98399	4	9688	98623	5	9738	98847	4	9788	99069	5	9838	99291	4	9888	99511	4	9938	99730	4	9988	99948	4
9639	98403	5	9689	98628	4	9739	98851	5	9789	99074	4	9839	99295	5	9889	99515	5	9939	99734	5	9989	99952	5
9640	98408	4	9690	98632	5	9740	98856	4	9790	99078	5	9840	99300	4	9890	99520	4	9940	99739	4	9990	99957	4
9641	98412	5	9691	98637	4	9741	98860	5	9791	99083	4	9841	99304	4	9891	99524	4	9941	99743	4	9991	99961	4
9642	98417	4	9692	98641	5	9742	98865	4	9792	99087	5	9842	99308	5	9892	99528	5	9942	99747	5	9992	99965	5
9643	98421	5	9693	98646	4	9743	98869	5	9793	99092	4	9843	99313	4	9893	99533	4	9943	99752	4	9993	99970	4
9644	98426	4	9694	98650	5	9744	98874	4	9794	99096	4	9844	99317	5	9894	99537	5	9944	99756	4	9994	99974	4
9645	98430	5	9695	98655	4	9745	98878	5	9795	99100	5	9845	99322	4	9895	99542	4	9945	99760	5	9995	99978	5
9646	98435	4	9696	98659	5	9746	98883	4	9796	99105	4	9846	99326	4	9896	99546	4	9946	99765	4	9996	99983	4
9647	98439	5	9697	98664	4	9747	98887	5	9797	99109	5	9847	99330	5	9897	99550	5	9947	99769	5	9997	99987	4
9648	98444	4	9698	98668	5	9748	98892	4	9798	99114	4	9848	99335	4	9898	99555	4	9948	99774	4	9998	99991	5
9649	98448	5	9699	98673	4	9749	98896	4	9799	99118	5	9849	99339	5	9899	99559	5	9949	99778	4	9999	99996	4
9650	98453		9700	98677		9750	98800		9800	99123		9850	99344		9900	99564		9950	99782		10000	10000	

LOGARITHMIC SINES AND TANGENTS.

0 Degrees.							
′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	*Inf. neg.*		0.00000	*Inf. neg.*		*Inf. posit.*	60
1	6.46373	30103	0.00000	6.46373	30103	13.53627	59
2	6.76476	17609	0.00000	6.76476	17609	13.23524	58
3	6.94085	12494	0.00000	6.94085	12494	13.05915	57
4	7.06579	9691	0.00000	7.06579	9691	12.93421	56
5	7.16270	7918	0.00000	7.16270	7918	12.83730	55
6	7.24188	6694	0.00000	7.24188	6694	12.75812	54
7	7.30882	5800	0.00000	7.30882	5800	12.69118	53
8	7.36682	5115	0.00000	7.36682	5115	12.63318	52
9	7.41797	4576	0.00000	7.41797	4576	12.58203	51
10	7.46373	4139	0.00000	7.46373	4139	12.53627	50
11	7.50512	3779	0.00000	7.50512	3779	12.49488	49
12	7.54291	3476	0.00000	7.54291	3476	12.45709	48
13	7.57767	3218	0.00000	7.57767	3219	12.42233	47
14	7.60985	2997	0.00000	7.60986	2996	12.39014	46
15	7.63986	2802	0.00000	7.63982	2803	12.36018	45
16	7.66784	2633	0.00000	7.66785	2633	12.23215	44
17	7.69417	2483	9.99999	7.69418	2482	12.30582	43
18	7.71900	2348	9.99999	7.71900	2348	12.28100	42
19	7.74248	2227	9.99999	7.72248	2228	12.25752	41
20	7.76475	2119	9.99999	7.76476	2119	12.23524	40
21	7.78594	2021	9.99999	7.78595	2020	12.21405	39
22	7.80615	1930	9.99999	7.80615	1931	12.19385	38
23	7.82545	1848	9.99999	7.82546	1848	12.17454	37
24	7.84393	1773	9.99999	7.84394	1773	12.15606	36
25	7.86166	1704	9.99999	7.86167	1704	12.13833	35
26	7.87870	1639	9.99999	7.87871	1639	12.12129	34
27	7.89509	1579	9.99999	7.89510	1579	12.10490	33
28	7.91088	1524	9.99999	7.91089	1524	12.08911	32
29	7.92612	1472	9.99998	7.92613	1473	12.07387	31
30	7.94084	1424	9.99998	7.94086	1424	12.05914	30
31	7.95508	1379	9.99998	7.95510	1379	12.04490	29
32	7.96887	1336	9.99998	7.96889	1336	12.03111	28
33	7.98223	1297	9.99998	7.98225	1297	12.01775	27
34	7.99520	1259	9.99998	7.99522	1259	12.00478	26
35	8.00779	1223	9.99998	8.00781	1223	11.99219	25
36	8.02002	1190	9.99998	8.02004	1190	11.97996	24
37	8.03192	1158	9.99997	8.03194	1159	11.96806	23
38	8.04350	1128	9.99997	8.04353	1128	11.95647	22
39	8.05478	1100	9.99997	8.05481	1100	11.94519	21
40	8.06578	1072	9.99997	8.06581	1072	11.93419	20
41	8.07650	1046	9.99997	8.07653	1047	11.92347	19
42	8.08696	1022	9.99997	8.08700	1022	11.91300	18
43	8.09718	999	9.99997	8.09722	998	11.90278	17
44	8.10717	976	9.99996	8.10720	976	11.89280	16
45	8.11693	954	9.99996	8.11696	955	11.88304	15
46	8.12647	934	9.99996	8.12651	934	11.87349	14
47	8.13581	914	9.99996	8.13585	915	11.86415	13
48	8.14495	896	9.99996	8.14500	895	11.85500	12
49	8.15391	877	9.99996	8.15395	878	11.84605	11
50	8.16268	860	9.99995	8.16273	860	11.83727	10
51	8.17128	843	9.99995	8.17133	843	11.82867	9
52	8.17971	827	9.99995	8.17976	828	11.82024	8
53	8.18798	812	9.99995	8.18804	812	11.81196	7
54	8.19610	797	9.99995	8.19616	797	11.80384	6
55	8.20407	782	9.99994	8.20413	782	11.79587	5
56	8.21189	769	9.99994	8.21195	769	11.78805	4
57	8.21958	755	9.99994	8.21964	756	11.78036	3
58	8.22713	743	9.99994	8.22720	742	11.77280	2
59	8.23456	730	9.99994	8.23362	730	11.76538	1
60	8.24186		9.99993	8.24192		11.75808	0
	Cos.		Sin.	Cot.		Tang.	
89 Degrees.							

1 Degree.							
′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	8.24186	717	9.99993	8.24192	718	11.75808	60
1	8.24903	706	9.99993	8.24910	706	11.75090	59
2	8.25609	695	9.99993	8.25616	696	11.74384	58
3	8.26304	684	9.99992	8.26312	684	11.73688	57
4	8.26988	673	9.99992	8.26996	673	11.73004	56
5	8.27661	663	9.99992	8.27669	663	11.72331	55
6	8.28324	653	9.99992	8.28332	654	11.71668	54
7	8.28977	644	9.99992	8.28986	643	11.71014	53
8	8.29621	634	9.99992	8.29629	634	11.70371	52
9	8.30255	625	9.99991	8.30263	625	11.69737	51
10	8.30879	616	9.99991	8.30888	617	11.69112	50
11	8.31495	608	9.99991	8.31505	607	11.68495	49
12	8.32103	599	9.99990	8.32112	599	11.67888	48
13	8.32702	590	9.99990	8.32711	591	11.67289	47
14	8.33292	583	9.99990	8.33302	581	11.66698	46
15	8.33875	575	9.99990	8.33886	575	11.66114	45
16	8.34450	568	9.99989	8.34461	568	11.65539	44
17	8.35018	560	9.99989	8.35029	561	11.64971	43
18	8.35578	553	9.99989	8.35590	553	11.64410	42
19	8.36131	547	9.99989	8.36143	546	11.63857	41
20	8.36678	539	9.99988	8.36689	540	11.63311	40
21	8.37217	533	9.99988	8.37229	533	11.62771	39
22	8.37750	526	9.99988	8.37762	527	11.62238	38
23	8.38276	520	9.99987	8.38289	520	11.61711	37
24	8.39796	514	9.99987	8.38809	514	11.61191	36
25	8.39310	508	9.99987	8.39323	509	11.60677	35
26	8.39818	502	9.99986	8.39832	502	11.60168	34
27	8.40320	496	9.99986	8.40334	496	11.59666	33
28	8.40816	491	9.99986	8.40830	491	11.59170	32
29	8.41307	485	9.99985	8.41321	486	11.58679	31
30	8.41792	480	9.99985	8.41807	480	11.58193	30
31	8.42272	474	9.99985	8.42287	475	11.57713	29
32	8.42746	470	9.99984	8.42762	470	11.57238	28
33	8.43216	464	9.99984	8.43232	464	11.56768	27
34	8.43680	459	9.99984	8.43696	460	11.56304	26
35	8.44739	455	9.99983	8.44156	455	11.55844	25
36	8.44594	450	9.99983	8.44611	450	11.55389	24
37	8.45044	445	9.99983	8.45061	446	11.54939	23
38	8.45489	441	9.99982	8.45507	441	11.54493	22
39	8.45930	436	9.99982	8.45948	437	11.54052	21
40	8.46366	433	9.99982	8.46385	432	11.53615	20
41	8.46799	427	9.99981	8.46817	428	11.53183	19
42	8.47226	424	9.99981	8.47245	424	11.52755	18
43	8.47650	419	9.99981	8.47669	420	11.52331	17
44	8.48069	416	9.99980	8.48089	416	11.51911	16
45	8.48485	411	9.99980	8.48505	412	11.51495	15
46	8.48896	408	9.99979	8.48917	408	11.51083	14
47	8.49304	404	9.99979	8.49325	404	11.50675	13
48	8.49708	400	9.99979	8.49729	401	11.50271	12
49	8.50108	396	9.99978	8.50130	397	11.49870	11
50	8.50504	393	9.99978	8.50527	393	11.49473	10
51	8.50897	390	9.99977	8.50920	390	11.49080	9
52	8.51287	386	9.99977	8.51310	386	11.48690	8
53	8.51673	382	9.99977	8.51696	383	11.48304	7
54	8.52055	379	9.99976	8.52079	380	11.47921	6
55	8.52434	376	9.99976	8.52459	376	11.47541	5
56	8.52810	373	9.99975	8.52835	373	11.47165	4
57	8.53183	369	9.99975	8.53208	370	11.46792	3
58	8.53552	367	9.99974	8.53578	367	11.46422	2
59	8.53919	363	9.99974	8.53945	363	11.46055	1
60	8.54282		9.99974	8.54308		11.45692	0
	Cos.		Sin.	Cot.		Tang.	
88 Degrees.							

LOGARITHMIC SINES AND TANGENTS.

2 Degrees.

′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	8.54282	360	9.99974	8.54308	361	11.45692	60
1	8.54642	357	9.99973	8.54669	358	11.45331	59
2	8.54999	355	9.99973	8.55027	355	11.44973	58
3	8.55354	351	9.99972	8.55382	352	11.44618	57
4	8.55705	349	9.99972	8.55734	349	11.44266	56
5	8.56054	346	9.99971	8.56083	346	11.43917	55
6	8.56400	343	9.99971	8.56429	344	11.43571	54
7	8.56743	341	9.99970	8.56773	341	11.43227	53
8	8.57084	337	9.99970	8.57114	348	11.42886	52
9	8.57421	336	9.99969	8.57452	356	11.42548	51
10	8.57757	332	9.99969	8.57788	333	11.42212	50
11	8.58089	330	9.99968	8.58121	330	11.41879	49
12	8.58419	328	9.99968	8.58451	328	11.41549	48
13	8.58747	325	9.99967	8.58779	326	11.41221	47
14	8.59072	323	9.99967	8.59105	323	11.40895	46
15	8.59395	320	9.99967	8.59428	321	11.40572	45
16	8.59715	318	9.99966	8.59749	319	11.40251	44
17	8.60033	316	9.99966	8.60068	316	11.39932	43
18	8.60349	313	9.99965	8.60384	314	11.39616	42
19	8.60662	311	9.99964	8.60698	311	11.39302	41
20	8.60973	309	9.99964	8.61009	310	11.38991	40
21	8.61282	307	9.99963	8.61319	307	11.38681	39
22	8.61589	305	9.99963	8.61626	305	11.38374	38
23	8.61894	302	9.92962	8.61931	303	11.38069	37
24	8.62196	301	9.99962	8.62234	301	11.37766	36
25	8.62497	298	9.99961	8.62535	299	11.37465	35
26	8.62795	296	9.99961	8.62834	297	11.37166	34
27	8.63091	294	9.99960	8.63131	295	11.36869	33
28	8.63385	293	9.99960	8.63426	292	11.36574	32
29	8.63678	290	9.99959	8.63718	291	11.36282	31
30	8.63968	288	9.99959	8.64009	289	11.35991	30
31	8.64256	287	9.99958	8.64298	287	11.35702	29
32	8.64543	284	9.99958	8.64585	285	11.35415	28
33	8.64827	283	9.99957	8.64870	284	11.35130	27
34	8.65110	281	9.99956	8.65154	281	11.34846	26
35	8.65391	279	9.99956	8.65435	280	11.34565	25
36	8.65670	277	9.99955	8.65715	278	11.34285	24
37	8.65947	276	9.99955	8.65993	276	11.34007	23
38	8.66223	274	9.99954	8.66269	274	11.33731	22
39	8.66497	272	9.99954	8.66543	273	11.33457	21
40	8.66769	270	9.99953	8.66816	271	11.33184	20
41	8.67039	269	9.99952	8.67087	269	11.32913	19
42	8.65308	267	9.99952	8.67356	268	11.32644	18
43	8.67575	266	9.99951	8.67624	266	11.32376	17
44	8.67841	263	9.99951	8.67890	264	11.32110	16
45	8.68104	263	9.99950	8.68154	263	11.31846	15
46	8.68367	260	9.99949	8.68417	261	18.31583	14
47	8.68627	259	9.99949	8.68678	260	11.31322	13
48	8.68886	258	9.99948	8.68938	258	11.31062	12
49	8.69144	256	9.99948	8.69196	257	11.30804	11
50	8.69400	254	9.99947	8.69453	255	11.30547	10
51	8.69654	253	9.99246	8.69708	254	11.30292	9
52	8.69907	252	9.99946	8.69962	252	11.30038	8
53	8.70159	250	9.99945	8.70214	251	11.29786	7
54	8.70409	249	9.99944	8.70465	249	11.29533	6
55	8.70658	247	9.99944	8.70714	248	11.29286	5
56	8.70905	246	9.99943	8.70962	246	11.29038	4
57	8.71151	244	9.99942	8.71208	245	11.28792	3
58	8.71395	243	9.99942	8.71453	244	11.28547	2
59	8.71638	242	9.99941	8.71697	243	11.28303	1
60	8.71880		9.99940	8.71940		11.28060	0
	Cos.		Sin.	Cot.		Tang.	

87 Degrees.

3 Degrees

′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	8.71880	240	9.99940	8.71940	241	11.28060	60
1	8.72120	239	9.99940	8.72181	239	11.27819	59
2	8.72359	238	9.99939	8.72420	239	11.27580	58
3	8.72597	237	9.99938	8.72659	237	11.27341	57
4	8.72834	235	9.99938	8.72896	236	11.27104	56
5	8.73069	234	9.99937	8.73132	234	11.26868	55
6	8.73303	232	9.99936	8.73366	234	11.26634	54
7	8.73535	232	9.99936	8.73600	232	11.26400	53
8	8.73767	230	9.99935	8.73832	231	11.26168	52
9	8.73997	229	9.99934	8.74063	229	11.25937	51
10	8.74226	228	9.99934	8.74292	229	11.25708	50
11	8.74454	226	9.99933	8.74521	227	11.25479	49
12	8.74680	226	9.99932	8.74748	226	11.25252	48
13	8.74906	224	9.99932	8.74974	225	11.25026	47
14	8.75130	223	9.99931	8.75199	224	11.24801	46
15	8.75353	222	9.99930	8.75423	222	11.24577	45
16	8.75575	220	9.99929	8.75645	222	11.24355	44
17	8.75795	220	9.99929	8.75867	220	11.24133	43
18	8.76015	219	9.99928	8.76087	219	11.23913	42
19	8.76234	217	9.99927	8.76306	219	11.23694	41
20	8.76451	216	9.99926	8.76525	217	11.23475	40
21	8.76667	216	9.99926	8.76742	216	11.23358	39
22	8.76883	214	9.99925	8.76958	215	11.23042	38
23	8.77097	213	9.99924	8.77173	214	11.22827	37
24	8.77310	212	9.99923	8.77387	213	11.22613	36
25	8.77522	211	9.99923	8.77600	211	11.22400	35
26	8.77733	210	9.99922	8.77811	211	11.22189	34
27	8.77943	209	9.99921	8.78022	210	11.21978	33
28	8.78152	208	9.99920	8.78232	209	11.21768	32
29	8.78360	208	9.99920	8.78441	208	11.21559	31
30	8.78568	206	9.99919	8.78649	206	11.21351	30
31	8.78774	205	9.99918	8.78855	206	11.21145	29
32	8.78979	204	9.99917	8.79061	205	11.20939	28
33	8.79183	203	9.99917	8.79266	204	11.20734	27
34	8.79386	202	9.99916	8.79470	203	11.20530	26
35	8.79588	201	9.99915	8.79673	202	11.20327	25
36	8.79789	201	9.99914	8.79875	201	11.20125	24
37	8.79990	199	9.99913	8.80076	201	11.19924	23
38	8.80189	199	9.99913	8.80277	199	11.19723	22
39	8.80388	197	9.99912	8.80476	198	11.19524	21
40	8.80585	197	9.99911	8.80674	198	11.19326	20
41	8.80782	196	9.99910	8.80872	196	11.19128	19
42	8.80978	195	9.99909	8.81068	196	11.18932	18
43	8.81173	194	9.99909	8.81264	195	11.18736	17
44	8.81367	193	9.99908	8.81459	194	11.18541	16
45	8.81560	192	9.99907	8.81653	193	11.18347	15
46	8.81752	192	9.99906	8.81846	192	11.18154	14
47	8.81944	190	9.99905	8.82038	192	11.17962	13
48	8.82134	190	9.99904	8.82230	190	11.17770	12
49	8.82324	189	9.99904	8.82420	190	11.17580	11
50	8.82513	188	9.99903	8.82610	189	11.17390	10
51	8.82701	187	9.99902	8.82799	188	11.17201	9
52	8.82888	187	9.99901	8.82987	188	11.17013	8
53	8.83075	186	9.99900	8.83175	186	11.16825	7
54	8.83261	185	9.99899	8.83361	186	11.16639	6
55	8.83446	184	9.99898	8.83547	185	11.16453	5
56	8.83630	183	9.99898	8.83732	184	11.16268	4
57	8.83813	183	9.99897	8.83916	184	11.16084	3
58	8.83996	181	9.99896	8.84100	182	11.15900	2
59	8.81177	181	8.99895	8.84284	182	11.15718	1
60	8.84358		9.99894	8.84464		11.15536	0
	Cos.		Sin.	Cot.		Tang.	

86 Degrees.

LOGARITHMIC SINES AND TANGENTS.

4 Degrees.

′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	8.84358	181	9.99894	8.84464	182	11.15536	60
1	8.84539	179	9.99893	8.84646	180	11.15354	59
2	8.84718	179	9.99892	8.84826	180	11.15174	58
3	8.84897	178	9.99891	8.85006	179	11.14994	57
4	8.85075	177	9.99891	8.85185	178	11.14815	56
5	8.85252	177	9.99890	8.85363	177	11.14637	55
6	8.85429	176	9.99889	8.85540	177	11.14460	54
7	8.85605	175	9.99888	8.85717	176	11.14283	53
8	8.85780	175	9.99887	8.85893	176	11.14107	52
9	8.85955	173	9.99886	8.86069	174	11.13931	51
10	8.86128	173	9.99885	8.86243	174	11.13757	50
11	8.86301	173	9.99884	8.86417	174	11.13583	49
12	8.86474	171	9.99883	8.86591	172	11.13409	48
13	8.86645	171	9.99882	8.86763	172	11.13237	47
14	8.86816	171	9.99881	8.86935	171	11.13065	46
15	8.86987	169	9.99880	8.87106	171	11.12894	45
16	8.87156	169	9.99879	8.87277	170	11.12723	44
17	8.87325	169	9.99879	8.87447	169	11.12553	43
18	8.87494	167	9.99878	8.87616	169	11.12384	42
19	8.87661	168	9.99877	8.87785	168	11.12215	41
20	8.87829	166	9.99876	8.87953	167	11.12047	40
21	8.87995	166	9.99875	8.88120	167	11.11880	39
22	8.88161	165	9.99874	8.88287	166	11.11713	38
23	8.88326	164	9.99873	8.88453	165	11.11547	37
24	8.88490	164	9.99872	8.88618	165	11.11382	36
25	8.88654	163	9.99871	8.88783	166	11.11217	35
26	8.88817	163	9.99870	8.88948	163	11.11052	34
27	8.88980	162	9.99869	8.89111	163	11.10889	33
28	8.89142	162	9.99868	8.89274	163	11.10726	32
29	8.89304	160	9.99867	8.89437	161	11.10563	31
30	8.89464	161	9.99866	8.89598	162	11.10402	30
31	8.89625	159	9.99865	8.89760	160	11.10240	29
32	8.89784	159	9.99864	8.89920	160	11.10080	28
33	8.89943	159	9.99863	8.90080	160	11.09920	27
34	8.90102	158	9.99862	8.90240	159	11.09760	26
35	8.90260	157	9.99861	8.90399	158	11.09601	25
36	8.90417	157	9.99860	8.90557	158	11.09443	24
37	8.90574	156	9.99859	8.90715	157	11.09285	23
38	8.90730	155	9.99858	8.90872	157	11.09128	22
39	8.90885	155	9.99857	8.91029	156	11.08971	21
40	8.91040	155	9.99856	8.91185	155	11.08815	20
41	8.91195	154	9.99855	8.91340	155	11.08660	19
42	8.91349	153	9.99854	8.91495	155	11.08505	18
43	8.91502	153	9.99853	8.91650	154	11.08350	17
44	8.91655	152	9.99852	8.91803	154	11.08197	16
45	8.91807	152	9.99851	8.91957	153	11.08043	15
46	8.91959	151	9.99850	8.92110	152	11.07890	14
47	8.92110	151	9.99848	8.92262	152	11.07738	13
48	8.92261	150	9.99847	8.92414	151	11.07586	12
49	8.92411	150	9.99846	8.92565	151	11.07435	11
50	8.92561	149	9.99845	8.92716	150	11.07284	10
51	8.92710	149	9.99844	8.92866	150	11.07134	9
52	8.92859	148	9.99843	8.93016	149	11.06984	8
53	8.93007	147	9.99842	8.93165	148	11.06835	7
54	8.93154	147	9.99841	8.93313	149	11.06687	6
55	8.93301	147	9.99840	8.93462	147	11.06538	5
56	8.93448	146	9.99839	8.93609	147	11.06391	4
57	8.93594	146	9.99838	8.93756	147	11.06244	3
58	8.93740	145	9.99837	8.93905	146	11.06027	2
59	8.93885	145	9.99836	8.94049	146	11.05951	1
60	8.94030		9.99834	8.94195		11.05805	0
	Cos.		Sin.	Cot.		Tang.	

85 Degrees.

5 Degrees.

′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	8.94030	144	9.99834	8.94195	145	11.05805	60
1	8.94174	143	9.99833	8.94340	145	11.05660	59
2	8.94317	144	9.99832	8.94485	145	11.05515	58
3	8.94461	142	9.99831	8.94630	143	11.05370	57
4	8.94603	143	9.99830	8.94773	144	11.05227	56
5	8.94746	141	9.99829	8.94917	143	11.05083	55
6	8.94887	142	9.99828	8.95060	142	11.0494	54
7	8.95029	141	9.99827	8.95202	142	11.04798	53
8	8.95170	140	9.99825	8.95344	142	11.04656	52
9	8.95310	140	9.99824	8.95486	141	11.04514	51
10	8.95450	139	9.99823	8.95627	140	11.04373	50
11	8.95589	139	9.99822	8.95767	141	11.04233	49
12	8.95728	139	9.99821	8.95908	139	11.04092	48
13	8.95867	138	9.99820	8.96047	140	11.03953	47
14	8.96005	138	9.99819	8.96187	138	11.03813	46
15	8.96143	137	9.99817	8.96325	139	11.03675	45
16	8.96280	137	9.99816	8.96464	138	11.03536	44
17	8.96417	136	9.99815	8.96602	137	11.03398	43
18	8.96553	136	9.99814	8.96739	138	11.03261	42
19	8.96689	136	9.99813	8.96877	136	11.03123	41
20	8.96825	135	9.99812	8.97013	137	11.02987	40
21	8.96960	135	9.99810	8.97150	135	11.02850	39
22	8.97095	134	9.99809	8.97285	136	11.02715	38
23	8.97229	134	9.99808	8.97421	135	11.02579	37
24	8.97363	133	9.99807	8.97556	135	11.02444	36
25	8.97496	133	9.99806	8.97691	134	11.02309	35
26	8.97629	133	9.99804	8.97825	134	11.02175	34
27	8.97762	132	9.99803	8.97959	133	11.02041	33
28	8.97894	132	9.99802	8.98092	133	11.01908	32
29	8.98026	131	9.99801	8.98225	133	11.01775	31
30	8.98157	131	9.99800	8.98358	132	11.01642	30
31	8.98288	131	9.99798	8.98490	132	11.01510	29
32	8.98419	130	9.99797	8.98622	131	11.01378	28
33	8.98549	130	9.99796	8.98753	131	11.01247	27
34	8.98679	129	9.99795	8.98884	131	11.01116	26
35	8.98808	129	9.99793	8.99015	130	11.00985	25
36	8.98937	129	9.99792	8.99145	130	11.00855	24
37	8.99066	128	9.99791	8.99275	130	11.00725	23
38	8.99194	128	9.99790	8.99405	129	11.00595	22
39	8.99322	128	9.99788	8.99534	128	11.00466	21
40	8.99450	127	9.99787	8.99662	129	11.00338	20
41	8.99577	127	9.99786	8.99791	128	11.00209	19
42	8.99704	126	9.99785	8.99919	127	11.00081	18
43	8.99830	126	9.99783	9.00046	128	10.99954	17
44	8.99956	126	9.99782	9.00174	127	10.99826	16
45	9.00082	125	9.99781	9.00301	126	10.99699	15
46	9.00207	125	9.99780	9.00427	126	10.99573	14
47	9.00332	124	9.99778	9.00553	126	10.99447	13
48	9.00456	125	9.99777	9.00679	126	10.99321	12
49	9.00581	123	9.99776	9.00805	125	10.99195	11
50	9.00704	124	9.99775	9.00930	125	10.99070	10
51	9.00828	123	9.99773	9.01055	124	10.98945	9
52	9.00951	123	9.99772	9.01179	124	10.98821	8
53	9.01074	122	9.99771	9.01303	124	10.98697	7
54	9.01196	122	9.99769	9.01427	123	10.98573	6
55	9.01318	122	9.99768	9.01550	123	10.98450	5
56	9.01440	121	9.99767	9.01673	123	10.98327	4
57	9.01561	121	9.99765	9.01796	122	10.98204	3
58	9.01682	121	9.99764	9.01918	122	10.98082	2
59	9.01803	120	9.99763	9.02040	122	10.97960	1
60	9.01923		9.99761	9.02162		10.97838	0
	Cos.		Sin.	Cot.		Tang.	

84 Degrees.

LOGARITHMIC SINES AND TANGENTS.

6 Degrees.

′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	9.01923	120	9.99761	9.02162	121	10.97838	60
1	9.02043	120	9.99760	9.02283	121	10.97717	59
2	9.02163	120	9.99759	9.02404	121	10.97596	58
3	9.02283	119	9.99757	9.02525	120	10.97475	57
4	9.02402	118	9.99756	9.02645	121	10.97355	56
5	9.02520	119	9.99755	9.02766	119	10.97234	55
6	9.02639	118	9.99753	9.02885	120	10.97115	54
7	9.02757	117	9.99752	9.03005	119	10.96995	53
8	9.02874	118	9.99751	9.03124	118	10.96876	52
9	9.02992	117	9.99749	9.03242	119	10.96758	51
10	9.03109	117	9.99748	9.03361	118	10.96639	50
11	9.03226	116	9.99747	9.03479	118	10.96521	49
12	9.03342	116	9.99745	9.03597	117	10.96403	48
13	9.03458	116	9.99744	9.03714	118	10.96286	47
14	9.03574	116	9.99742	9.03832	116	10.96168	46
15	9.03690	115	9.99741	9.03948	117	10.96052	45
16	9.03805	115	9.99740	9.04065	116	10.95935	44
17	9.03920	114	9.99738	9.04181	116	10.95819	43
18	9.04034	115	9.99737	9.04297	116	10.95703	42
19	9.04149	113	9.99736	9.04413	115	10.95587	41
20	9.04262	114	9.99734	9.04528	115	10.95472	40
21	9.04376	114	9.99733	9.04643	115	10.95357	39
22	9.04490	113	9.99731	9.04758	115	10.95242	38
23	9.04603	112	9.99730	9 04873	114	10.95127	37
24	9.04715	113	9.99728	9.04987	114	10.95013	36
25	9.04828	112	9.99727	9.05101	113	10.94899	35
26	9.04940	112	9.99726	9.05214	114	10.94786	34
27	9.05052	112	9.99724	9.05328	113	10.94672	33
28	9.05164	111	9.99723	9.05341	112	10.94559	32
29	9.05275	111	9.99721	9.05553	113	10.94447	31
30	9.05386	111	9.99720	9.05666	112	10.94334	30
31	9.05497	110	9.99718	9.05778	112	10.94222	29
32	9.05607	110	9.99717	9.05890	112	10.94110	28
33	9.05717	110	9.99716	9.06002	111	10.93998	27
34	9.05827	110	9.99714	9.06113	111	10.93887	26
35	9.05937	109	9.99713	9.06224	111	10.93776	25
36	9.06046	109	9.99711	9.06335	110	10.93665	24
37	9.06155	109	9.99710	9.06445	111	10.93555	23
38	9.06264	108	9.99708	9.06556	110	10.93444	22
39	9.06372	109	9.99707	9.06666	109	10.93334	21
40	9.06481	108	9.99705	9.06775	110	10.93225	20
41	9.06589	107	9.99704	9.06885	109	10.93115	19
42	9.06696	108	9.99702	9.06994	109	10 93006	18
43	9 06804	107	9.99701	9.07103	108	10.92897	17
44	9.06911	107	9.99699	9.07211	109	10.92789	16
45	9.07018	106	9.99698	9.07320	108	10.92680	15
46	9.07124	107	9.99696	9.07428	108	10.92572	14
47	9.07231	106	9.99695	9.07536	107	10.92464	13
48	9.07337	105	9.99693	9.07643	108	10.92357	12
49	9.07442	106	9.99692	9.07751	107	10.92249	11
50	9.07548	105	9.99690	9.07858	106	10.92142	10
51	9.07653	105	9.99689	9.07964	107	10.92036	9
52	9.07758	105	9.99687	9.08071	106	10.91929	8
53	9.07863	105	9.99686	9.08177	106	10.91823	7
54	9 07968	104	9.99684	9.08283	106	10.91717	6
55	9.08072	104	9.99683	9.08389	106	10.91611	5
56	9.08176	104	9.99681	9.08495	105	10.91505	4
57	9.08280	103	9.99680	9.08600	105	10.91400	3
58	9 08383	103	9.99678	9.08705	105	10 91295	2
59	9.08486	103	9.99677	9.08810	104	10.91190	1
60	9.08589		9.99675	9.08914		10.91086	0
	Cos.		Sin.	Cot.		Tang.	

83 Degrees.

7 Degrees.

′	Sin.	Dif.	Cos.	Tang.	Dif.	Cot.	′
0	9.08589	103	9.99675	9.08914	105	10.91086	60
1	9.08692	103	9.99674	9.09019	104	10.90981	59
2	9.08795	102	9.99672	9.09123	104	10.90877	58
3	9.08897	102	9.99670	9.09227	103	10.90773	57
4	9.08999	102	9.99669	9.09330	104	10.90670	56
5	9.09101	101	9.99667	9.09434	103	10.90566	55
6	9.09202	102	9.99666	9.09537	103	10.90463	54
7	9.09304	101	9.99664	9.09640	102	10.90360	53
8	9.09405	101	9.99663	9.09742	103	10.90258	52
9	9.09506	100	9.99661	9.09845	102	10.90155	51
10	9.09606	101	9.99659	9.09947	102	10.90053	50
11	9.09707	100	9.99658	9.10049	101	10.89951	49
12	9.09807	100	9.99656	9.10150	102	10.89850	48
13	9.09907	99	9.99655	9.10252	101	10.89748	47
14	9.10006	100	9 99653	9.10353	101	10.89647	46
15	9.10106	99	9.99651	9.10454	101	10.89546	45
16	9.10205	99	9.99650	9.10555	101	10.89445	44
17	9.10304	98	9.99648	9.10656	100	10.89344	43
18	9.10402	99	9.99647	9.10756	100	10.89244	42
19	9.10501	98	9.99645	9.10856	100	10.89144	41
20	9.10599	98	9.99643	9.10956	100	10.89044	40
21	9.10697	98	9.99642	9.11056	99	10.88944	39
22	9.10795	98	9.99640	9.11155	99	10.88845	38
23	9.10893	97	9.99638	9.11254	99	10.88746	37
24	9.10990	97	9.99637	9.11353	99	10.88647	36
25	9.11087	97	9.99635	9.11452	99	10.88548	35
26	9.11184	97	9.99633	9.11551	98	10.88449	34
27	9.11281	96	9.99632	9.11649	98	10.88351	33
28	9.11377	97	9.99630	9.11747	98	10.88253	32
29	9.11474	96	9.99629	9.11845	98	10.88155	31
30	9.11570	96	9.99627	9.11943	97	10.88057	30
31	9.11666	95	9.99625	9.12040	98	10.87960	29
32	9.11761	96	9.99624	9.12138	97	10 87862	28
33	9.11857	95	9.99622	9.12235	97	10.87765	27
34	9.11952	95	9.99620	9.12332	96	10.87668	26
35	9.12047	95	9 99618	9.12428	97	10.87573	25
36	9.12142	94	9.99617	9.12525	96	10.87475	24
37	9.12236	95	9.99615	9.12621	96	10.87379	23
38	9.12231	94	9.99613	9.12717	96	10.87283	22
39	9.12425	94	9.99612	9.12813	96	10.87187	21
40	9.12519	93	9.99610	9.12909	95	10.87091	20
41	9.12612	94	9.99608	9.13004	95	10.86996	19
42	9.12706	93	9.99607	9.13099	95	10.86901	18
43	9.12799	93	9.99605	9.13194	95	10.86806	17
44	9.12892	93	9.99603	9 13289	95	10.86711	16
45	9.12985	93	9.99601	9.13384	94	10.86616	15
46	9.13078	93	9.99600	9.13478	95	10.86522	14
47	9.13171	92	9.99598	9.13573	94	10 86427	13
48	9.13263	92	9.99596	9.13667	94	10.86333	12
49	9.13355	92	9.99595	9.13761	93	10.86239	11
50	9.13447	92	9.99593	9.13854	94	10.86146	10
51	9.13539	91	9.99591	9.13948	93	10.86052	9
52	9.13630	92	9.99589	9.14041	93	10 85959	8
53	9.13722	91	9.99588	9.14134	93	10.85866	7
54	9.13813	91	9.99586	9.14227	93	10.85773	6
55	9.13904	90	9.99584	9.14320	92	10.85680	5
56	9.13994	91	9.99582	9.14412	92	10 85588	4
57	9.14085	90	9.99581	9.14504	93	10.85496	3
58	9.14175	91	9.99579	9.14597	91	10.85403	2
59	9.14266	90	9.99577	9.14688	92	10 85312	1
60	9.14356		9.99575	9.14780		10.85220	0
	Cos.		Sin.	Cot.		Tang.	

82 Degrees.

LOGARITHMIC SINES AND TANGENTS.

8 Degrees.

′	Sin.	D.	Cos.	Tang.	D.	Cot.	′
0	9.14356	89	9.99575	9.14780	92	10.85220	60
1	9.14445	90	9.99574	9.14872	91	10.85128	59
2	9.14535	89	9.99572	9.14963	91	10.85037	58
3	9.14624	90	9.99570	9.15054	91	10.84946	57
4	9.14714	89	9.99568	9.15145	91	10.84855	56
5	9.14803	88	9.99566	9.15236	91	10.84764	55
6	9.14891	89	9.99565	9.15327	90	10.84673	54
7	9.14980	89	9.99563	9.15417	91	10.84583	53
8	9.15069	88	9.99561	9.15508	90	10.84492	52
9	9.15157	88	9.99559	9.15598	90	10.84402	51
10	9.15245	88	9.99557	9.15688	89	10.84312	50
11	9.15333	88	9.99556	9.15777	90	10.84223	49
12	9.15421	87	9.99554	9.15867	89	10.84133	48
13	9.15508	88	9.99552	9.15956	90	10.84044	47
14	9.15596	87	9.99550	9.16046	89	10.83954	46
15	9.15683	87	9.99548	9.16135	89	10.83865	45
16	9.15770	87	9.99546	9.16224	88	10.83776	44
17	9.15857	87	9.99545	9.16312	89	10.83688	43
18	9.15944	86	9.99543	9.16401	88	10.83599	42
19	9.16030	86	9.99541	9.16489	88	10.83511	41
20	9.16116	87	9.99539	9.16577	88	10.83423	40
21	9.16203	86	9.99537	9.16665	88	10.83335	39
22	9.16289	85	9.99535	9.16753	88	10.83247	38
23	9.16374	86	9.99533	9.16841	87	10.83159	37
24	9.16460	85	9.99532	9.16928	88	10.83072	36
25	9.16545	86	9.99530	9.17016	87	10.82984	35
26	9.16631	85	9.99528	9.17103	87	10.82897	34
27	9.16716	85	9.99526	9.17190	87	10.82810	33
28	9.16801	85	9.99524	9.17277	86	10.82723	32
29	9.16886	84	9.99522	9.17363	87	10.82637	31
30	9.16970	85	9.99520	9.17450	86	10.82550	30
31	9.17055	84	9.99518	9.17536	86	10.82464	29
32	9.17139	84	9.99517	9.17622	86	10.82378	28
33	9.17223	84	9.99515	9.17708	86	10.82292	27
34	9.17307	84	9.99513	9.17794	86	10.82206	26
35	9.17391	83	9.99511	9.17880	85	10.82120	25
36	9.17474	84	9.99509	9.17965	86	10.82035	24
37	9.17558	83	9.99507	9.18051	85	10.81949	23
38	9.17641	83	9.99505	9.18136	85	10.81864	22
39	9.17724	83	9.99503	9.18221	85	10.81779	21
40	9.17807	83	9.99501	9.18306	85	10.81694	20
41	9.17890	83	9.99499	9.18391	84	10.81609	19
42	9.17973	82	9.99497	9.18475	85	10.81525	18
43	9.18055	82	9.99495	9.18560	84	10.81440	17
44	9.18137	83	9.99494	9.18644	84	10.81356	16
45	9.18220	82	9.99492	9.18728	84	10.81272	15
46	9.18302	81	9.99490	9.18812	8	10.81188	14
47	9.18383	82	9.99488	9.18896	83	10.81104	13
48	9.18465	82	9.99486	9.18979	84	10.81021	12
49	9.18547	81	9.99484	9.19063	83	10.80937	11
50	9.18628	81	9.99482	9.19146	83	10.80854	10
51	9.18709	81	9.99480	9.19229	83	10.80771	9
52	9.18790	81	9.99478	9.19312	83	10.80688	8
53	9.18871	81	9.99476	9.19395	83	10.80605	7
54	9.18952	81	9.99474	9.19478	83	10.80522	6
55	9.19033	80	9.99472	9.19561	82	10.80439	5
56	9.19113	80	9.99470	9.19643	82	10.80357	4
57	9.19193	80	9.99468	9.19725	82	10.80275	3
58	9.19273	80	9.99466	9.19807	82	10.80193	2
59	9.19353	80	9.99464	9.19889	82	10.80111	1
60	9.19433		9.99462	9.19971		10.80029	0
	Cos.		Sin	Cot.		Tang.	

81 Degrees.

9 Degrees.

′	Sin.	D	Cos.	Tang.	D.	Cot.	′
0	9.19433	80	9.99462	9.19971	82	10.80029	60
1	9.19513	79	9.99460	9.20053	81	10.79947	59
2	9.19592	80	9.99458	9.20134	82	10.79866	58
3	9.19672	79	9.99456	9.20116	81	10.79784	57
4	9.19751	79	9.99454	9.20297	81	10.79703	56
5	9.19830	79	9.99452	9.20378	81	10.79622	55
6	9.19909	79	9.99450	9.20459	81	10.79541	54
7	9.19988	79	9.99448	9.20540	81	10.79460	53
8	9.20067	78	9.99446	9.20621	80	10.79379	52
9	9.20145	78	9.99444	9.20701	81	10.79299	51
10	9.20223	79	9.99442	9.20782	80	10.79218	50
11	9.20302	78	9.99440	9.20862	80	10.79138	49
12	9.20380	78	9.99438	9.20942	8	10.79058	48
13	9.20458	77	9.99436	9.21022	80	10.78978	47
14	9.20535	78	9.99434	9.21102	80	10.78898	46
15	9.20613	78	9.99432	9.21182	79	10.78818	45
16	9.20691	77	9.99429	9.21261	80	10.78739	44
17	9.20768	77	9.99427	9.21341	79	10.78659	43
18	9.20845	77	9.99425	9.21420	79	10.78580	42
19	9.20922	77	9.99423	9.21499	79	10.78501	41
20	9.20999	77	9.99421	9.21578	79	10.78422	40
21	9.21079	77	9.99419	9.21657	79	10.78343	39
22	9.21153	76	9.99417	9.21736	78	10.78264	38
23	9.21229	77	9.99415	9.21814	79	10.78186	37
24	9.21306	76	9.99413	9.21893	78	10.78107	36
25	9.21382	76	9.99411	9.21971	78	10.78029	35
26	9.21458	76	9.99409	9.22049	78	10.77951	34
27	9.21534	76	9.99406	9.22127	78	10.77873	33
28	9.21610	75	9.99404	9.22205	78	10.77795	32
29	9.21685	76	9.99402	9.22283	78	10.77717	31
30	9.21761	75	9.99400	9.22361	77	10.77639	30
31	9.21836	76	9.99398	9.22438	78	10.77562	29
32	9.21912	75	9.99396	9.22516	77	10.77484	28
33	9.21987	75	9.99394	9.22593	77	10.77407	27
34	9.22062	75	9.99392	9.22670	77	10.77330	26
35	9.22137	74	9.99390	9.22747	77	10.77253	25
36	9.22211	75	9.99388	9.22824	77	10.77176	24
37	9.22286	75	9.99385	9.22901	76	10.77099	23
38	9.22361	74	9.99383	9.22977	77	10.77023	22
39	9.22435	74	9.99381	9.23054	76	10.76946	21
40	9.22509	74	9.99379	9.23130	76	10.76870	20
41	9.22583	74	9.99377	9.23206	77	10.76794	19
42	9.22657	74	9.99375	9.23283	76	10.76717	18
43	9.22731	74	9.99372	9.23359	76	10.76641	17
44	9.22805	73	9.99370	9.23435	75	10.76565	16
45	9.22878	74	9.99368	9.23510	76	10.76490	15
46	9.22952	73	9.99366	9.23586	75	10.76414	14
47	9.23025	73	9.99364	9.23661	76	10.76339	13
48	9.23098	73	9.99362	9.23737	75	10.76263	12
49	9.23171	73	9.99359	9.23812	75	10.76188	11
50	9.23244	73	9.99357	9.23887	75	10.76113	10
51	9.23317	73	9.99355	9.23962	75	10.76038	9
52	9.23390	72	9.99353	9.24037	75	10.75963	8
53	9.23462	73	9.99351	9.24112	74	10.75888	7
54	9.23535	72	9.99348	9.24186	75	10.75814	6
55	9.23607	72	9.99346	9.24261	74	10.75739	5
56	9.23679	71	9.99344	9.24335	75	10.75665	4
57	9.23752	71	9.99342	9.24410	74	10.75590	3
58	9.23823	72	9.99340	9.24484	74	10.75516	2
59	9.23895	72	9.99337	9.24558	74	10.75442	1
60	9.23967		9.99335	9.24632		10.75368	0
	Cos.		Sin.	Cot.		Tang.	

80 Degrees.

LOGARITHMIC SINES AND TANGENTS.

10 Degrees.

′	Sin.	D.	Cos.	Tang.	D	Cot.	′
0	9.23967	72	9.99335	9.24632	74	10.75368	60
1	9.24039	71	9.99333	9.24706	73	10.75294	59
2	9.24110	71	9.99331	9.24779	74	10.75221	58
3	9.24181	72	9.99328	9.24853	73	10.75147	57
4	9.24253	71	9.99326	9.24926	74	10.75074	56
5	9.24324	71	9.99324	9.25000	73	10.75000	55
6	9.24395	71	9.99322	9.25073	73	10.74927	54
7	9.24466	70	9.99319	9.25146	73	10.74854	53
8	9.24536	71	9.99317	9.25219	73	10.74781	52
9	9.24607	70	9.99315	9.25292	72	10.74708	51
10	9.24677	71	9.99313	9.25365	72	10.74635	50
11	9.24748	70	9.99310	9.25437	73	10.74563	49
12	9.24818	70	9.99308	9.25510	72	10.74490	48
13	9.24888	70	9.99306	9.25582	73	10.74418	47
14	9.24958	70	9.99304	9.25655	72	10.74345	46
15	9.25028	70	9.99301	9.25727	72	10.74273	45
16	9.25098	70	9.99299	9.25799	72	10.74201	14
17	9.25168	69	9.99297	9.25871	72	10.74129	43
18	9.25237	70	9.99294	9.25943	72	10.74057	42
19	9.25307	69	9.99292	9.26015	71	10.73985	41
20	9.25376	69	9.99290	9.26086	72	10.73914	40
21	9.25445	69	9.99288	9.26158	71	10.73842	39
22	9.25514	69	9.99285	9.26229	72	10.73771	38
23	9.25583	69	9.99283	9.26301	71	10.73699	37
24	9.25652	69	9.99281	9.26372	71	10.73628	36
25	9.25721	69	9.99278	9.26443	71	10.73557	35
26	9.25790	68	9.99276	9.26514	71	10.72486	34
27	9.25858	69	9.99274	9.26585	70	10.73415	33
28	9.25927	68	9.99271	9.26655	71	10.73345	32
29	9.25995	68	9.99269	9.26726	71	10.73274	31
30	9.26063	68	9.99267	9.26797	70	10.73203	30
31	9.26131	68	9.99264	9.26867	70	10.73133	29
32	9.26199	68	9.99262	9.26937	71	10.73063	28
33	9.26267	58	9.99260	9.27008	70	10.72992	27
34	9.26335	68	9.99257	9.27078	70	10.72922	26
35	9.26403	67	9.99255	9.27148	70	10.72852	25
36	9.26470	68	9.99252	9.27218	70	10.72782	24
37	9.26538	67	9.99250	9.27288	69	10.72712	23
38	9.26605	67	9.99248	9.27357	70	10.72643	22
39	9.26672	67	9.99245	9.27427	59	10.72573	21
40	9.26739	67	9.99243	9.27496	70	10.72504	20
41	9.26806	67	9.99241	9.27566	69	10.72434	19
42	9.26873	67	9.99238	9.27635	69	10.72365	18
43	9.26940	67	9.99236	9.27704	69	10.72296	17
44	9.27007	66	9.99233	9.27773	69	10.72227	16
45	9.27073	67	9.99231	9.27842	69	10.72158	15
46	9.27140	66	9.99229	9.27911	69	10.72089	14
47	9.27206	67	9.99226	9.27980	69	10.72020	13
48	9.27273	66	9.99224	9.28049	68	10.71951	12
49	9.27339	66	9.99221	9.28117	69	10.71883	11
50	9.27405	66	9.99219	9.28186	68	10.71814	10
51	9.27471	66	9.99217	9.28254	69	10.71746	9
52	9.27537	65	9.99214	9.28323	68	10.71677	8
53	9.27602	66	9.99212	9.28391	68	10.71609	7
54	9.27668	66	9.99209	9.28459	68	10.71541	6
55	9.27734	65	9.99207	9.28527	68	10.71473	5
56	9.27799	65	9.99204	9.28595	67	10.71405	4
57	9.27864	66	9.99202	9.28662	68	10.71338	3
58	9.27930	65	9.99200	9.28730	68	10.71270	2
59	9.27995	65	9.99197	9.28798	67	10.71202	1
60	9.28060		9.99195	9.28865		10.71135	0
	Cos.		Sin.	Cot.		Tang.	

79 Degrees.

11 Degrees.

′	Sin.	D.	Cos.	Tang.	D.	Cot.	′
0	9.28060	65	9.99195	9.28865	68	10.71135	60
1	9.28125	65	9.99192	9.28933	67	10.71067	59
2	9.28190	64	9.99190	9.29000	67	10.71000	58
3	9.28254	65	9.99187	9.29067	67	10.70933	57
4	9.28319	65	9.99185	9.29134	67	10.70866	56
5	9.28384	64	9.99182	9.29201	67	10.70799	55
6	9.28448	64	9.99180	9.29268	67	10.70732	54
7	9.28512	65	9.99177	9.29335	67	10.70665	53
8	9.28577	64	9.99175	9.29402	65	10.70598	52
9	9.28641	64	9.99172	9.29468	66	10.70532	51
10	9.28705	64	9.99170	9.29535	66	10.70465	50
11	9.28769	64	9.99167	9.29601	67	10.70399	49
12	9.38833	63	9.99165	9.29668	66	10.70332	48
13	9.28896	64	9.99162	9.29734	66	10.70266	47
14	9.28960	64	9.99160	9.29800	66	10.70200	46
15	9.29023	53	9.99157	9.29866	66	10.70134	45
16	9.29087	63	9.99155	9.29932	66	10.70068	44
17	9.29150	64	9.99152	9.29998	66	10.70002	43
18	9.29214	63	9.99150	9.30064	66	10.69936	42
19	9.29277	63	9.99147	9.30130	65	10.69870	41
20	9.29340	63	9.99145	9.30195	66	10.69805	40
21	9.29403	63	9.99142	9.30261	65	10.69739	39
22	9.29466	63	9.99140	9.30326	65	10.69674	38
23	9.29529	62	9.99137	9.30391	66	10.69609	37
24	9.29591	63	9.99135	9.30457	65	10.69543	36
25	9.29654	62	9.99132	9.30522	65	10.69478	35
26	9.29716	63	9.99130	9.30587	65	10.69413	34
27	9.29779	62	9.99127	9.30652	65	10.69348	33
28	9.29841	62	9.99124	9.30717	65	10.69283	32
29	9.29903	63	9.99122	9.30782	64	10.69218	31
30	9.29966	62	9.99119	9.30846	65	10.69154	30
31	9.30028	62	9.99117	9.30911	64	10.69089	29
32	9.30090	61	9.99114	9.30975	65	10.69025	28
33	9.30151	62	9.99112	9.31040	64	10.68960	27
34	9.30213	62	9.99109	9.31104	64	10.68896	26
35	9.30275	61	9.99106	9.31168	65	10.68832	25
36	9.30336	62	9.99104	9.31233	64	10.68767	24
37	9.30398	61	9.99101	9.31297	64	10.68703	23
38	9.30459	62	9.99099	9.31361	64	10.68639	22
39	9.30521	61	9.99096	9.31425	64	10.68575	21
40	9.30582	61	9.99093	9.31489	63	10.68511	20
41	9.30643	61	9.99091	9.31552	64	10.68448	19
42	9.30704	61	9.99088	9.31616	63	10.68384	18
43	9.30765	61	9.99086	9.31679	64	10.68321	17
44	9.30826	61	9.99083	9.31743	63	10.68257	16
45	9.30887	60	9.99080	9.31806	64	10.68194	15
46	9.30947	61	9.99078	9.31870	63	10.68130	14
47	9.31008	60	9.99075	9.31933	63	10.68067	13
48	9.31068	61	9.99072	9.31996	63	10.68004	12
49	9.31129	60	9.99070	9.32059	63	10.67941	11
50	9.31189	61	9.99067	9.32122	63	10.67878	10
51	9.31250	60	9.99064	9.32185	63	10.67815	9
52	9.31310	60	9.99062	9.32248	63	10.67752	8
53	9.31370	60	9.99059	9.32311	62	10.67689	7
54	9.31430	60	9.99056	9.32373	63	10.67627	6
55	9.31490	59	9.99054	9.32436	62	10.67564	5
56	9.31549	60	9.99051	9.32498	63	10.67502	4
57	9.31609	60	9.99048	9.32561	62	10.67439	3
58	9.31669	59	9.99046	9.32623	62	10.67377	2
59	9.31728	60	9.99043	9.32685	62	10.67315	1
60	9.31788		9.99040	9.32747		10.67253	0
	Cos.		Sin.	Cot.		Tang.	

78 Degrees.

LOGARITHMIC SINES AND TANGENTS.

12 Degrees.							
′	Sin.	D.	Cos.	Tang.	D	Cot.	′
0	9.31788	59	9.99040	9.32747	63	10.67253	60
1	9.31847	60	9.99038	9.32810	62	10.67190	59
2	9.31907	59	9.99035	9.32872	61	10.67128	58
3	9.31966	59	9.99032	9.32933	62	10.67067	57
4	9.32025	59	9.99030	9.32995	62	10.67005	56
5	9.32084	59	9.99027	9.33057	62	10.66943	55
6	9.32143	59	9.99024	9.33119	61	10.66881	54
7	9.32202	59	9.99022	9.33180	62	10.66820	53
8	9.32261	58	9.99019	9.33242	61	10.66758	52
9	9.32319	59	9.99016	9.33303	62	10.66697	51
10	9.32378	59	9.99013	9.33365	61	10.66635	50
11	9.32437	58	9.99011	9.33426	61	10.66574	49
12	9.32495	58	9.99008	9.33487	61	10.66513	48
13	9.32553	59	9.99005	9.33548	61	10.66452	47
14	9.32612	58	9.99002	9.33609	61	10.66391	46
15	9.32670	58	9.99000	9.33670	61	10.66330	45
16	9.32728	58	9.98997	9.33731	61	10.66269	44
17	9.32786	58	9.98993	9.33792	61	10.66208	43
18	9.32844	58	9.98991	9.33853	60	10.66147	42
19	9.32902	58	9.98989	9.33913	61	10.66087	41
20	9.32960	58	9.98986	9.33974	60	10.66026	40
21	9.33018	57	9.98983	9.34034	61	10.65966	39
22	9.33075	58	9.98980	9.34095	60	10.65905	38
23	9.33133	57	9.98978	9.34155	60	10.65845	37
24	9.33190	58	9.98975	9.34215	61	10.65785	36
25	9.33248	57	9.98972	9.34276	60	10.65724	35
26	9.33305	57	9.98969	9.34336	60	10.65664	34
27	9.33362	58	9.98967	9.34396	60	10.65604	33
28	9.33420	57	9.98964	9.34456	60	10.65544	32
29	9.33477	57	9.98961	9.34516	60	10.65484	31
30	9.33534	57	9.98958	9.34576	59	10.65424	30
31	9.33591	56	9.98955	9.34635	60	10.65365	29
32	9.33647	57	9.98953	9.34695	60	10.65305	28
33	9.33704	57	9.98950	9.34755	59	10.65245	27
34	9.33761	57	9.98947	9.34814	60	10.65186	26
35	9.33818	56	9.98944	9.34874	59	10.65126	25
36	9.33874	57	9.98941	9.34933	59	10.65067	24
37	9.33931	56	9.98938	9.34992	59	10.65008	23
38	9.33987	56	9.98936	9.35051	60	10.64949	22
39	9.34043	57	9.98933	9.35111	59	10.64889	21
40	9.34100	56	9.98930	9.35170	59	10.64830	20
41	9.34156	56	9.98927	9.35229	59	10.64771	19
42	9.34212	56	9.98924	9.35288	59	10.64712	18
43	9.34268	56	9.98921	9.35347	58	10.64653	17
44	9.34324	56	9.98919	9.35405	59	10.64595	16
45	9.34380	56	9.98916	9.35464	59	10.64536	15
46	9.34436	55	9.98913	9.35523	58	10.64477	14
47	9.34491	56	9.98910	9.35581	59	10.64419	13
48	9.34547	55	9.98907	9.35640	58	10.64360	12
49	9.34602	56	9.98904	9.35698	59	10.64302	11
50	9.34658	55	9.98901	9.35757	58	10.64243	10
51	9.34713	56	9.98898	9.35815	58	10.64185	9
52	9.34769	55	9.98896	9.35873	58	10.64127	8
53	9.34824	55	9.98893	9.35931	58	10.64069	7
54	9.34879	55	9.98890	9.35989	58	10.64011	6
55	9.34934	55	9.98887	9.36047	58	10.63953	5
56	9.34989	55	9.98884	9.36105	58	10.63895	4
57	9.35044	55	9.98881	9.36163	58	10.63837	3
58	9.35099	55	9.98878	9.36221	58	10.63779	2
59	9.35154	55	9.98875	9.36279	57	10.63721	1
60	9.35209		9.98872	9.36336		10.63664	0
′	Cos.		Sin.	Cot.		Tang.	
77 Degrees.							

13 Degrees.							
′	Sin.	D.	Cos.	Tang.	D.	Cot.	′
0	9.35209	54	9.98872	9.36336	58	10.63664	60
1	9.35263	55	9.98869	9.36394	58	10.63606	59
2	9.35318	55	9.98867	9.36452	57	10.63548	58
3	9.35373	54	9.98864	9.36509	57	10.63491	57
4	9.35427	54	9.98861	9.36566	58	10.63434	56
5	9.35481	55	9.98858	9.36624	57	10.63376	55
6	9.35536	54	9.98855	9.36681	57	10.63319	54
7	9.35590	54	9.98852	9.36738	57	10.63262	53
8	9.35644	54	9.98849	9.36795	57	10.63205	52
9	9.35698	54	9.98846	9.36852	57	10.63148	51
10	9.35752	54	9.98843	9.36909	57	10.63091	50
11	9.35806	54	9.98840	9.36966	57	10.63034	49
12	9.35860	54	9.98837	9.37023	57	10.62977	48
13	9.35914	54	9.98834	9.37080	57	10.62920	47
14	9.35968	54	9.98831	9.37137	56	10.62863	46
15	9.36022	53	9.98828	9.37193	57	10.62807	45
16	9.36075	54	9.98825	9.37250	56	10.62750	44
17	9.36129	53	9.98822	9.37306	57	10.62694	43
18	9.36182	54	9.98819	9.37363	56	10.62637	42
19	9.36236	53	9.98816	9.37419	57	10.62581	41
20	9.36289	53	9.98813	9.37476	56	10.62524	40
21	9.36342	53	9.98810	9.37532	56	10.62468	39
22	9.36395	54	9.98807	9.37588	56	10.62412	38
23	9.36449	53	9.98804	9.37644	56	10.62356	37
24	9.36502	53	9.98801	9.37700	56	10.62300	36
25	9.36555	53	9.98798	9.37756	56	10.62244	35
26	9.36608	52	9.98795	9.37812	56	10.62188	34
27	9.36660	53	9.98792	9.37868	56	10.62132	33
28	9.36718	53	9.98789	9.37924	56	10.62076	32
29	9.36766	53	9.98786	9.37980	55	10.62020	31
30	9.36819	52	9.98783	9.38035	56	10.61965	30
31	9.36871	53	9.98780	9.38091	56	10.61909	29
32	9.36924	52	9.98777	9.38147	55	10.61853	28
33	9.36976	52	9.98774	9.38202	55	10.61798	27
34	9.37028	53	9.98771	9.38257	56	10.61743	26
35	9.37081	52	9.98768	9.38313	55	10.61687	25
36	9.37133	52	9.98765	9.38368	55	10.61632	24
37	9.37185	52	9.98762	9.38423	56	10.61577	23
38	9.37237	52	9.98759	9.38479	55	10.61521	22
39	9.37289	52	9.98756	9.38534	55	10.61466	21
40	9.37341	52	9.98753	9.38589	55	10.61411	20
41	9.37393	52	9.98750	9.38644	55	10.61356	19
42	9.37445	52	9.98746	9.38699	55	10.61301	18
43	9.37497	52	9.98743	9.38754	54	10.61246	17
44	9.37549	51	9.98740	9.38808	55	10.61192	16
45	9.37600	52	9.98737	9.38863	55	10.61137	15
46	9.37652	51	9.98734	9.38918	54	10.61082	14
47	9.37703	52	9.98731	9.38972	55	10.61028	13
48	9.37755	51	9.98728	9.39027	55	10.60973	12
49	9.37806	52	9.98725	9.39082	54	10.60918	11
50	9.37858	51	9.98722	9.39136	54	10.60864	10
51	9.37909	51	9.98719	9.39190	55	10.60810	9
52	9.37960	51	9.98715	9.39245	54	10.60755	8
53	9.38011	51	9.98712	9.39299	54	10.60701	7
54	9.38062	51	9.98709	9.39353	54	10.60647	6
55	9.38113	51	9.98706	9.39407	54	10.60593	5
56	9.38164	51	9.98703	9.39461	54	10.60539	4
57	9.38215	51	9.98700	9.39515	54	10.60485	3
58	9.38266	51	9.98697	9.39569	54	10.60431	2
59	9.38317	51	9.98694	9.39623	54	10.60377	1
60	9.38368		9.98690	9.39677		10.60323	0
′	Cos.		Sin.	Cot.		Tang.	
76 Degrees.							

LOGARITHMIC SINES AND TANGENTS.

14 Degrees.							
′	Sin.	D.	Cos.	Tang.	D.	Cot.	′
0	9.38368	50	9.98690	9.39677	54	10.60323	60
1	9.38418	51	9.98687	9.39731	54	10.60269	59
2	9.38469	50	9.98684	9.39785	53	10.60215	58
3	9.38519	51	9.98681	9.39838	54	10.60162	57
4	9.38570	50	9.98678	9.39892	53	10.60108	56
5	9.38620	50	9.98675	9.39945	54	10.60055	55
6	9.38670	51	9.98671	9.39999	53	10.60001	54
7	9.38721	50	9.98668	9.40052	54	10.59948	53
8	9.38771	50	9.98665	9.40106	53	10.59894	52
9	9.48821	50	9.98662	9.40159	53	10.59841	51
10	9.38871	50	9.98659	9.40212	54	10.59788	50
11	9.38921	50	9.98656	9.40266	53	10.59734	49
12	9.38971	50	9.98652	9.40319	53	10.59681	48
13	9.39021	50	9.98649	9.40372	53	10.59628	47
14	9.39071	50	9.98646	9.40425	53	10.59575	46
15	9.39121	49	9.98643	9.40478	53	10.59522	45
16	9.39170	50	9.98640	9.40531	53	10.59469	44
17	9.39220	50	9.98636	9.40584	52	10.59416	43
18	9.39270	49	9.98633	9.40636	53	10.59364	42
19	9.39319	50	9.98630	9.40689	53	10.59311	41
20	9.39369	49	9.98627	9.40742	53	10.59258	40
21	9.39418	49	9.98623	9.40795	52	10.59205	39
22	9.39467	50	9.98620	9.40847	53	10.59153	38
23	9.39517	49	9.98617	9.40900	52	10.59100	37
24	9.39566	49	9.98614	9.40952	53	10.59048	36
25	9.39615	49	9.98610	9.41005	52	10.58995	35
26	9.39664	49	9.98607	9.41057	52	10.58943	34
27	9.39713	49	9.98604	9.41109	52	10.58891	33
28	9.39762	49	9.98601	9.41161	53	10.58839	32
29	9.39811	49	9.98597	9.41214	52	10.58786	31
30	9.39860	49	9.98594	9.41266	52	10.58734	30
31	9.39909	49	9.98591	9.41318	52	10.58682	29
32	9.39958	48	9.98588	9.41370	52	10.58630	28
33	9.40006	49	9.98584	9.41422	52	10.58578	27
34	9.40055	48	9.98581	9.41474	52	10.58526	26
35	9.40103	49	9.98578	9.41526	52	10.58474	25
36	9.40152	48	9.98574	9.41578	51	10.58422	24
37	9.40200	49	9.98571	9.41629	52	10.58371	23
38	9.40249	48	9.98568	9.41681	52	10.58319	22
39	9.40297	49	9.98565	9.41733	51	10.58267	21
40	9.40346	48	9.98561	9.41784	52	10.58216	20
41	9.40394	48	9.98558	9.41836	51	10.58164	19
42	9.40442	48	9.98555	9.41887	52	10.58113	18
43	9.40490	48	9.98551	9.41939	51	10.58061	17
44	9.40538	48	9.98548	9.41990	51	10.58010	16
45	9.40586	48	9.98545	9.42041	52	10.57959	15
46	9.40634	48	9.98541	9.42093	51	10.57907	14
47	9.40682	48	9.98538	9.42144	51	10.57856	13
48	9.40730	48	9.98535	9.42195	51	10.57805	12
49	9.40778	47	9.98531	9.42246	51	10.57754	11
50	9.40825	48	9.98528	9.42297	51	10.57703	10
51	9.40873	48	9.98525	9.42348	51	10.57652	9
52	9.40921	47	9.98521	9.42399	51	10.57601	8
53	9.40968	48	9.98518	9.42450	51	10.57550	7
54	9.41015	47	9.98515	9.42501	51	10.57499	6
55	9.41063	48	9.98511	9.42552	51	10.57448	5
56	9.41111	47	9.98508	9.42603	50	10.57397	4
57	9.41158	47	9.98505	9.42653	51	10.57347	3
58	9.41205	47	9.98501	9.42704	51	10.57296	2
59	9.41252	48	9.98498	9.42755	50	10.57245	1
60	9.41300		9.98494	9.42805		10.57195	0
	Cos.		Sin.	Cot.		Tang.	
75 Degrees.							

15 Degrees.							
′	Sin.	D.	Cos.	Tang.	D.	Cot.	′
0	9.41300	47	9.98494	9.42805	51	10.57195	60
1	9.41347	47	9.98491	9.42856	50	10.57144	59
2	9.41394	47	9.98488	9.42906	51	10.57094	58
3	9.41441	47	9.98484	9.42957	50	10.57043	57
4	9.41448	47	9.98481	9.43007	50	10.56993	56
5	9.41535	47	9.98477	9.43057	51	10.56943	55
6	9.41582	46	9.98474	9.43108	50	10.56892	54
7	9.41628	47	9.98471	9.43158	50	10.56842	53
8	9.41675	47	9.98467	9.43208	50	10.56792	52
9	9.41722	46	9.98464	9.43258	50	10.56742	51
10	9.41768	47	9.98460	9.43308	50	10.56692	50
11	9.41815	46	9.98457	9.43358	50	10.56642	49
12	9.41861	47	9.98453	9.43408	50	10.56592	48
13	9.41908	46	9.98450	9.43458	50	10.56542	47
14	9.41954	47	9.98447	9.43508	50	10.56492	46
15	9.42001	46	9.98443	9.43558	49	10.56442	45
16	9.42047	46	9.98440	9.43607	50	10.56393	44
17	9.42093	47	9.98436	9.43657	50	10.56343	43
18	9.42140	46	9.98433	9.43707	49	10.56293	42
19	9.42186	46	9.98429	9.43756	50	10.56244	41
20	9.42232	46	9.98426	9.43806	49	10.56194	40
21	9.42278	46	9.98422	9.43855	50	10.56145	39
22	9.42324	46	9.98419	9.43905	49	10.56095	38
23	9.42370	46	9.98415	9.43954	50	10.56046	37
24	9.42416	45	9.98412	9.44004	49	10.55996	36
25	9.42461	46	9.98409	9.44053	49	10.55947	35
26	9.42507	46	9.98405	9.44102	49	10.55898	34
27	9.42553	46	9.98402	9.44151	50	10.55849	33
28	9.42599	45	9.98398	9.44201	49	10.55799	32
29	9.42644	46	9.98395	9.44250	49	10.55750	31
30	9.42690	45	9.98391	9.44299	49	10.55701	30
31	9.42735	46	9.98388	9.44348	49	10.55652	29
32	9.42781	45	9.98384	9.44397	49	10.55603	28
33	9.42826	46	9.98381	9.44446	49	10.55554	27
34	9.42872	45	9.98377	9.44495	49	10.55505	26
35	9.42917	45	9.98373	9.44544	48	10.55456	25
36	9.42962	46	9.98370	9.44592	49	10.55408	24
37	9.43008	45	9.98366	9.44641	49	10.55359	23
38	9.43053	45	9.98363	9.44690	48	10.55310	22
39	9.43098	45	9.98359	9.44738	49	10.55262	21
40	9.43143	45	9.98356	9.44787	49	10.55213	20
41	9.43188	45	9.98352	9.44836	48	10.55164	19
42	9.43233	45	9.98349	9.44884	49	10.55116	18
43	9.43278	45	9.98345	9.44933	48	10.55067	17
44	9.43323	44	9.98342	9.44981	48	10.55019	16
45	9.43367	45	9.98338	9.45029	49	10.54971	15
46	9.43412	45	9.98334	9.45078	48	10.54922	14
47	9.43457	45	9.98331	9.45126	48	10.54874	13
48	9.43502	44	9.98327	9.45174	48	10.54826	12
49	9.43546	45	9.98324	9.45222	49	10.54778	11
50	9.43591	44	9.98320	9.45271	48	10.54729	10
51	9.43635	45	9.98317	9.45319	48	10.54681	9
52	9.43680	44	9.98313	9.45367	48	10.54633	8
53	9.43724	45	9.98309	9.45415	48	10.54585	7
54	9.43769	44	9.98306	9.45463	48	10.54537	6
55	9.43813	44	9.98302	9.45511	48	10.54489	5
56	9.43857	44	9.98299	9.45559	47	10.54441	4
57	9.43901	45	9.98295	9.45606	48	10.54394	3
58	9.43946	44	9.98291	9.45654	48	10.54346	2
59	9.43990	44	9.98288	9.45702	48	10.54298	1
60	9.44034		9.98284	9.45750		10.54250	0
	Cos.		Sin.	Cot.		Tang.	
74 Degrees.							

LOGARITHMIC SINES AND TANGENTS.

16 Degrees.

′	Sin.	D.	Cos.	Tang.	D.	Cot.	′
0	9.44034	44	9.98284	9.45755	47	10.54250	60
1	9.44078	44	9.98281	9.45797	48	10.54203	59
2	9.44122	44	9.98277	9.45845	47	10.54155	58
3	9.44166	44	9.98273	9.45892	48	10.54108	57
4	9.44210	43	9.98270	9.45940	47	10.54060	56
5	9.44253	44	9.98266	9.45987	48	10.54013	55
6	9.44297	44	9.98262	9.46035	47	10.53965	54
7	9.44341	44	9.98259	9.46082	48	10.53918	53
8	9.44385	43	9.98255	9.46130	47	10.53870	52
9	9.44428	44	9.98251	9.46177	47	10.53823	51
10	9.44472	44	9.98248	9.46224	47	10.53776	50
11	9.44516	43	9.98244	9.46271	48	10.53729	49
12	9.44559	43	9.98240	9.46319	47	10.53681	48
13	9.44602	44	9.98237	9.46366	47	10.53634	47
14	9.44646	43	9.98233	9.46413	47	10.53587	46
15	9.44689	44	9.98229	9.46460	47	10.53500	45
16	9.44733	43	9.98226	9.46507	47	10.53493	44
17	9.44776	43	9.98222	9.46554	47	10.53446	43
18	9.44819	43	9.98218	9.46601	47	10.53399	42
19	9.44862	43	9.98215	9.46648	46	10.53352	41
20	9.44905	43	9.98211	9.46694	47	10.53306	40
21	9.44948	44	9.98207	9.46741	47	10.53259	39
22	9.44992	43	9.98204	9.46788	47	10.53212	38
23	9.45035	42	9.98200	9.46835	46	10.53165	37
24	9.45077	43	9.98196	9.46881	47	10.53119	36
25	9.45120	43	9.98192	9.46928	47	10.53072	35
26	9.45163	43	9.98189	9.46975	46	10.53025	34
27	9.45206	43	9.98185	9.47021	47	10.52979	33
28	9.45249	43	9.98181	9.47068	46	10.52932	32
29	9.45292	42	9.98177	9.47114	46	10.52886	31
30	9.45334	42	9.98174	9.47160	47	10.52840	30
31	9.45377	42	9.98170	9.47207	46	10.52793	29
32	9.45419	43	9.98166	9.47253	46	10.52747	28
33	9.45462	42	9.98162	9.47299	47	10.52701	27
34	9.45504	43	9.98159	9.47346	46	10.52654	26
35	9.45547	42	9.98155	9.47392	46	10.52608	25
36	9.45589	43	9.98151	9.47438	46	10.52562	24
37	9.45632	42	9.98147	9.47484	46	10.52516	23
38	9.45674	42	9.98144	9.47530	46	10.52470	22
39	9.45716	42	9.98140	9.47576	46	10.52424	21
40	9.45758	43	9.98136	9.47622	46	10.52378	20
41	9.45801	42	9.98132	9.47668	46	10.52332	19
42	9.45843	42	9.98129	9.47714	46	10.52286	18
43	9.45885	42	9,98125	9.47760	46	10.52240	17
44	9.45927	42	9.98121	9.47806	46	10.52194	16
45	9.45969	42	9.98117	9.47852	45	10.52148	15
46	9.46011	42	9.98113	9.47897	46	10.52103	14
47	9.46053	42	9.98110	9.47943	46	10.52057	13
48	9.46095	41	9.98106	9.47989	46	10.52011	12
49	9.46136	42	9.98102	9.48035	45	10.51965	11
50	9.46178	42	9.98098	9.48080	46	10.51920	10
51	9.46220	42	9.98094	9.48126	45	10.51874	9
52	9.46262	41	9.98090	9.48171	46	10.51829	8
53	9.46303	42	9.98087	9.48217	45	10.51783	7
54	9.46345	41	9.98083	9.48262	45	10.51738	6
55	9.46386	42	9.98079	9.48307	46	10.51693	5
56	9.46428	41	9.98075	9.48353	45	10.51647	4
57	9.46469	42	9.98071	9.48398	45	10.51602	3
58	9.46511	41	9.98067	9.48443	46	10.51557	2
59	9.46552	42	9.98063	9.48489	45	10.51511	1
60	9.46594		9.98060	9.48534		10.51466	0
	Cos		Sin.	Cot.		Tang.	

73 Degrees.

17 Degrees.

′	Sin	D	Cos.	Tang.	D.	Cot.	′
0	9.46594	41	9.98060	9.48534	45	10.51466	60
1	9.46635	41	9.98056	9.48579	45	10.51421	59
2	9.46676	41	9.98052	9.48624	45	10.51376	58
3	9.46717	41	9.98048	9.48669	45	10.51331	57
4	9.46758	42	9.98044	9.48714	45	10.51286	56
5	9.46800	42	9.98040	9.48759	45	10.51241	55
6	9.46841	41	9.98036	9.48804	45	10.51196	54
7	9.46882	41	9.98032	9.48849	45	10.51151	53
8	9.46923	41	9.98029	9.48894	45	10.51106	52
9	9.46964	41	9.98025	9.48939	45	10.51061	51
10	9.47005	40	9.98021	9.48984	45	10.51016	50
11	9.47045	41	9.98017	9.49029	44	10.50971	49
12	9.47086	41	9.98013	9.49073	45	10.50927	48
13	9.47127	41	9.98009	9.49118	45	10.50882	47
14	9.47168	41	9.98005	9.49163	44	10.50837	46
15	9.47209	40	9.98001	9.49207	45	10.50793	45
16	9.47249	41	9.97997	9.49252	44	10.50748	44
17	9.47290	40	9.97993	9.49296	45	10.50704	43
18	9.47330	41	9.97989	9.49341	14	10.50659	42
19	9.47371	40	9.97986	9.49385	45	10.50615	41
20	9.47411	41	9.97982	9.49430	44	10.50570	40
21	9.47452	40	9.97978	9.49474	45	10.50526	39
22	9.47492	41	9.97974	9.49519	44	10.50481	38
23	9.47533	40	9.97970	9.49563	44	10.50437	37
24	9.47573	40	9.97962	9.49607	45	10.50393	36
25	9.47613	41	9.97966	9.49652	44	10.50348	35
26	9.47654	40	9.97958	9.49696	44	10.50304	34
27	9.47694	40	9.97954	9.49740	44	10.50260	33
28	9.47734	40	9.97950	9.49784	44	10.50216	32
29	9.47774	40	9.97946	9.49828	44	10.50172	31
30	9.47814	40	9.97942	9.49872	44	10.50128	30
31	9.47854	40	9.97938	9.49916	44	10.50084	29
32	9.47894	40	9.97934	9.49960	44	10.50040	28
33	9.47934	40	9.97930	9.50004	44	10.49996	27
34	9.47974	40	9.97926	9.50048	44	10.49952	26
35	9.48014	40	9.97922	9.50092	44	10.49908	25
36	9.48054	40	9.97918	9.50136	44	10.49864	24
37	9.48094	39	9.97914	9.50180	43	10.49820	23
38	9.48133	40	9.97910	9.50223	44	10.49777	22
39	9.48173	40	9.97906	9.50267	44	10.49733	21
40	9.48213	39	9.97902	9.50311	44	10.49689	20
41	9.48252	40	9.97898	9.50355	43	10.49645	19
42	9.48292	40	9.97894	9.50398	44	10.49602	18
43	9.48332	39	9.97890	9.50442	43	10.49558	17
44	9.48371	40	9.97886	9.50485	44	10.49515	16
45	9.48411	39	9.97882	9.50529	43	10.49471	15
46	9.48450	40	9.97878	9.50572	44	10.49428	14
47	9.48490	39	9.97874	9.50616	43	10.49384	13
48	9.48529	39	9.97870	9.50659	44	10.49341	12
49	9.48568	39	9.97866	9.50703	43	10.49297	11
50	9.48607	40	9.97861	9.50746	43	10.49254	10
51	9.48647	39	9.97857	9.50789	44	10.49211	9
52	9.48686	39	9.97853	9.50833	43	10.49167	8
53	9.48725	39	9.97849	9.50876	43	10.49124	7
54	9.48764	39	9.97845	9.50919	43	10.49081	6
55	9.48803	39	9.97841	9.50962	43	10.49038	5
56	9.48842	39	9.97837	9.51005	43	10.48995	4
57	9.48881	39	9.97833	9.51048	43	10.48952	3
58	9.48920	39	9.97829	9.51092	43	10.48908	2
59	9.48959	39	9.97825	9.51135	43	10.48865	1
60	9.48998		9.97821	9.51178		10.48822	0
	Cos.		Sin.	Cot.		Tang.	

72 Degrees.

LOGARITHMIC SINES AND TANGENTS.

18 Degrees.

′	Sin.	D.	Cos.	D	Tang.	D	Cot.	′
0	9.48998	39	9.97821	4	9.51178	43	10.48822	60
1	9.49037	39	9.97817	5	9.51221	43	10.48779	59
2	9.49076	39	9.97812	4	9.51264	42	10.48736	58
3	9.49115	38	9.97808	4	9.51306	43	10.48694	57
4	9.49153	39	9.97804	4	9.51349	43	10.48651	56
5	9.49192	39	9.97800	4	9.51302	43	10.48608	55
6	9.49231	38	9.97796	4	9.51435	43	10.48565	54
7	9.49269	39	9.97792	4	9.51478	42	10.48522	53
8	9.49308	39	9.97788	4	9.51520	43	10.48480	52
9	9.49347	38	9.97784	5	9.51563	43	10.48437	51
10	9.49385	39	9.97779	4	9.51606	42	10.48394	50
11	9.49424	38	9.97775	4	9.51648	43	10.48352	49
12	9.49462	38	9.97771	4	9.51691	43	10.48309	48
13	9.49500	39	9.97767	4	9.51734	42	10.48266	47
14	9.49539	38	9.97763	4	9.51776	43	10.48224	46
15	9.49577	38	9.97759	5	9.51819	42	10.48181	45
16	9.49615	39	9.97754	4	9.51861	42	10.48139	44
17	9.49654	38	9.97750	4	9.51903	43	10.48097	43
18	9.49692	38	9.97746	4	9.51946	42	10.48054	42
19	9.49730	38	9.97742	4	9.51988	43	10.48012	41
20	9.49768	38	9.97738	4	9.52031	42	10.47969	40
21	9.49806	38	9.97734	5	9.52073	42	10.47927	39
22	9.49844	38	9.97729	4	9.52115	42	10.47885	38
23	9.49882	38	9.97725	4	9.52157	43	10.47843	37
24	9.49920	38	9.97721	4	9.52200	42	10.47800	36
25	9.49958	38	9.97717	4	9.52242	42	10.47758	35
26	9.49996	38	9.97713	5	9.52284	42	10.47716	34
27	9.50034	38	9.97708	4	9.52326	42	10.47674	33
28	9.50072	38	9.97704	4	9.52368	42	10.47632	32
29	9.50110	38	9.97700	4	9.52410	42	10.47590	31
30	9.50148	37	9.97696	5	9.52452	42	10.47548	30
31	9.50185	38	9.97691	4	9.52494	42	10.47506	29
32	9.50223	38	9.97687	4	9.52536	42	10.47464	28
33	9.50261	37	9.97683	4	9.52578	42	10.47422	27
34	9.50298	38	9.97579	5	9.52620	41	10.47380	26
35	9.50336	38	9.97674	4	9.52661	42	10.47339	25
36	9.50374	37	9.97670	4	9.52703	42	10.47297	24
37	9.50411	38	9.97666	4	9.52745	42	10.47255	23
38	9.50449	37	9.97662	5	9.52787	42	10.47213	22
39	9.50486	37	9.97657	4	9.52829	41	10.47171	21
40	9.50523	38	9.97653	4	9.52870	42	10.47130	20
41	9.50561	37	9.97649	4	9.52912	41	10.47088	19
42	9.50598	37	9.97645	5	9.52953	42	10.47047	18
43	9.50635	38	9.97640	4	9.52995	42	10.47005	17
44	9.50673	37	9.97636	4	9.53037	41	10.46963	16
45	9.50710	37	9.97632	4	9.53078	42	10.46922	15
46	9.50747	37	9.97628	5	9.53120	41	10.46880	14
47	9.50784	37	9.97623	4	9.53161	41	10.46839	13
48	9.50821	37	9.97619	4	9.53202	42	10.46798	12
49	9.50858	38	9.97615	5	9.53244	41	10.46756	11
50	9.50896	37	9.97610	4	9.53285	42	10.46715	10
51	9.50933	37	9.97606	4	9.53327	41	10.46673	9
52	9.50970	37	9.97602	5	9.53368	41	10.46632	8
53	9.51007	36	9.97597	4	9.53409	41	10.46591	7
54	9.51043	37	9.97593	4	9.53450	42	10.46550	6
55	9.51080	37	9.97589	5	9.53492	41	10.46508	5
56	9.51117	37	9.97584	4	9.53533	41	10.46467	4
57	9.51154	37	9.97580	4	9.53574	41	10.46426	3
58	9.5119	36	9.97576	5	9.53615	41	10.46385	2
5	9.51227	37	9.97571	4	9.53656	41	10.46344	1
60	9.51264		9.97567		9.53697		10.46303	0
	Cos.		Sin.		Cot.		Tang.	

71 Degrees.

19 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.51264	37	9.97567	4	9.53697	41	10.46303	60
1	9.51301	37	9.97563	5	9.53738	41	10.46262	59
2	9.51338	36	9.97558	4	9.53779	41	10.46221	58
3	9.51374	37	9.97554	4	9.53820	41	10.46180	57
4	9.51411	36	9.97550	5	9.53861	41	10.46139	56
5	9.51447	37	9.97545	4	9.53902	41	10.46098	55
6	9.51484	36	9.97541	5	9.53943	41	10.46057	54
7	9.51520	37	9.97536	4	9.53984	41	10.46016	53
8	9.51557	36	9.97532	4	9.54025	40	10.45975	52
9	9.51593	36	9.97528	5	9.54065	41	10.45935	51
10	9.51629	37	9.97523	4	9.54106	41	10.45894	50
11	9.51666	36	9.97519	4	9.54147	40	10.45853	49
12	9.51702	36	9.97515	5	9.54187	41	10.45813	48
13	9.51738	36	9.97510	4	9.54228	41	10.45772	47
14	9.51774	37	9.97506	5	9.54269	40	10.45731	46
15	9.51811	36	9.97501	5	9.54309	41	10.45691	45
16	9.51847	36	9.97497	5	9.54350	40	10.45650	44
17	9.51883	36	9.97492	4	9.54390	41	10.45610	43
18	9.51919	36	9.97488	4	9.54431	40	10.45569	42
19	9.51955	36	9.97484	5	9.54471	41	10.45529	41
20	9.51991	36	9.97479	4	9.54512	40	10.45488	40
21	9.52027	36	9.97475	5	9.54552	41	10.45448	39
22	9.52063	36	9.97470	4	9.54593	40	10.45407	38
23	9.52099	36	9.97466	5	9.54633	40	10.45367	37
24	9.52135	36	9.97461	4	9.54673	41	10.45327	36
25	9.52171	36	9.97457	4	9.54714	40	10.45286	35
26	9.52207	35	9.97453	5	9.54754	40	10.45246	34
27	9.52242	36	9.97448	4	9.54794	41	10.45206	33
28	9.52278	36	9.97444	5	9.54835	40	10.45165	32
29	9.52314	36	9.97439	4	9.54875	40	10.45125	31
30	9.52350	35	9.97435	5	9.54915	40	10.45084	30
31	9.52385	36	9.97430	4	9.54955	40	10.45045	29
32	9.52421	35	9.97426	5	9.54995	40	10.45005	28
33	9.52456	36	9.97421	4	9.55035	40	10.44965	27
34	9.52492	35	9.97417	5	9.55075	40	10.44925	26
35	9.52527	36	9.97412	4	9.55115	40	10.44885	25
36	9.52563	35	9.97408	5	9.55155	40	10.44845	24
37	9.52598	36	9.97403	4	9.55195	40	10.44805	23
38	9.52634	35	9.97399	5	9.55235	40	10.44765	22
39	9.52669	36	9.97394	4	9.55275	40	10.44725	21
40	9.52705	35	9.97390	5	9.55315	40	10.44685	20
41	9.52740	35	9.97385	4	9.55355	40	10.44645	19
42	9.52775	36	9.97381	5	9.55395	39	10.44605	18
43	9.52811	35	9.97376	4	9.55434	40	10.44566	17
44	9.52846	35	9.97372	5	9.55474	40	10.44526	16
45	9.52881	35	9.97367	4	9.55414	40	10.44486	15
46	9.52916	35	9.97363	5	9.55554	39	10.44446	14
47	9.52951	35	9.97359	5	9.55593	40	10.44407	13
48	9.52986	35	9.97353	4	9.55633	40	10.44367	12
49	9.53021	35	9.97349	5	9.55673	39	10.44327	11
50	9.53056	36	9.97344	4	9.55712	40	10.44288	10
51	9.53092	34	9.97340	5	9.55752	39	10.44248	9
52	9.53126	35	9.97335	4	9.55791	40	10.44209	8
53	9.53161	35	9.97331	5	9.55831	39	10.44169	7
54	9.53196	35	9.97326	4	9.55870	40	10.44130	6
55	9.53231	35	9.97322	5	9.55910	39	10.44090	5
56	9.53266	35	9.97317	5	9.55949	40	10.44051	4
57	9.53301	35	9.97312	4	9.55989	39	10.44011	3
58	9.53336	34	9.97308	5	9.56028	39	10.43972	2
59	9.53370	35	9.97303	4	9.56067	40	10.43933	1
60	9.53405		9.97299		9.56107		10.43893	0
	Cos.		Sin.		Cot.		Tang.	

70 Degrees.

LOGARITHMIC SINES AND TANGENTS.

20 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.53405	35	9.97299	5	9.56107	39	10.43893	60
1	9.53440	35	9.97294	5	9.56146	39	10.43854	59
2	9.53475	34	9.97289	4	9.56185	39	10.43815	58
3	9.53509	35	9.97295	5	9.56224	40	10.43776	57
4	9.53544	34	9.97280	4	9.56264	39	10.43736	56
5	9.53578	35	9.97276	5	9.56303	39	10.43697	55
6	9.53613	34	9.97271	5	9.56342	39	10.43658	54
7	9.53647	35	9.97266	4	9.56381	39	10.43619	53
8	9.53682	34	9.97262	5	9.56420	39	10.43580	52
9	9.53786	35	9.97257	5	9.56459	39	10.43541	51
10	9 53751	34	9.97252	4	9 56498	39	10.43502	50
11	9.53785	34	9.97248	5	9.56537	39	10.43463	49
12	9.53819	35	9.97243	5	9.56576	39	10.43424	48
13	9 53854	34	9.97238	4	9.56615	39	10.43385	47
14	9.53888	34	9.97234	5	9.56654	39	10.43346	46
15	9.53922	35	9.97229	5	9.56693	39	10.43307	45
16	9.53957	34	9.97224	4	9.56732	39	10.43268	44
17	9 53991	34	9.97220	5	9.56771	39	10.43229	43
18	9.54025	34	9.97215	5	9.56810	39	10.43190	42
19	9.54059	34	9.97210	4	9.56849	38	10.43151	41
20	9.54093	34	9.97206	5	9.56887	39	10.43113	40
21	9.54127	34	9.97201	5	9.56926	39	10.43074	39
22	9.54161	34	9 97196	4	9.56965	39	10.43035	38
23	9.54195	34	9.97192	5	9.57004	38	10 42996	37
24	9.54229	34	9.97187	5	9.57042	39	10.42958	36
25	9.54263	34	9.97182	4	9.57081	39	10 42919	35
26	9.54297	34	9.97178	5	9.57120	38	10.42880	34
27	9.54331	34	9.97173	5	9.57158	39	10.42842	33
28	9.54365	34	9.97168	5	9.57197	38	10.42803	32
29	9.54399	34	9.97163	4	9.57235	39	10.42765	31
30	9 54433	33	9.97159	5	9.57274	38	10.42726	30
31	9.54466	34	9.97154	5	9.57312	39	10.42688	29
32	9.54500	34	9 97149	4	9.57351	38	10.42649	28
33	9.54534	33	9.97145	5	9.57389	39	10.42611	27
34	9.54567	34	9.97140	5	9.57428	38	10.42572	26
35	9.54601	34	9.97135	5	9.57466	38	10.42534	25
36	9.54635	33	9.97130	4	9.57504	39	10.42496	24
37	9.54668	34	9.97126	5	9.57543	38	10.42457	23
38	9.54702	33	9.97121	5	9.57581	38	10.42419	22
39	9.54735	34	9.97116	5	9.57619	39	10.42381	21
40	9.54769	33	9.97111	4	9.57658	38	10.42342	20
41	9.54802	34	9 97107	5	9.57696	38	10.42304	19
42	9.54836	33	9.97102	5	9.57734	38	10.42266	18
43	9.54869	34	9.97097	5	9.57772	38	10.42228	17
44	9.54903	33	9.97092	5	9 57810	39	10.42190	16
45	9.54936	33	9.97087	4	9.57849	38	10.42151	15
46	9.54969	34	9.97083	5	9.57887	38	10.42113	14
47	9.55003	33	9.97078	5	9.57925	38	10.42075	13
48	9.55036	33	9.97073	5	9.57963	38	10.42037	12
49	9.55069	33	9.97068	5	9.58001	38	10.41999	11
50	9 55102	34	9.97063	4	9.58039	38	10.41961	10
51	9.55136	33	9 97059	5	9.58077	38	10.41923	9
52	9.55169	33	9.97054	5	9.58115	38	10.41885	8
53	9.55202	33	9.97049	5	9.58153	38	10.41847	7
54	9.55235	33	9.97044	5	9.58191	38	10.41809	6
55	9.55258	33	9.97039	4	9.58229	38	10.41771	5
56	9.55301	33	9.97035	5	9.58267	37	10.41733	4
57	9.55334	33	9.97030	5	9.58304	38	10.41696	3
58	9.55367	33	9.97025	5	9.58342	38	10.41658	2
59	9.55400	33	9.97020	5	9.58380	38	10.41620	1
60	9.55423		9.97015		9.58418		10.41582	0
	Cos.		Sin.		Cot.		Tang.	

69 Degrees.

21 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.55433	33	9.97015	5	9.58418	37	10.41582	60
1	9.55466	33	9.97010	5	9.58455	38	10.41545	59
2	9.55499	33	9.97005	4	9.58493	38	10.41507	58
3	9.55532	32	9.97001	5	9.58531	38	10.41469	57
4	9.55564	33	9.96996	5	9.58569	37	10.41431	56
5	9.55597	33	9.96991	5	9.58606	38	10.41394	55
6	9.55630	33	9.96986	5	9.58644	37	10.41356	54
7	9.55663	32	9.96981	5	9.58681	38	10.41319	53
8	9.55695	33	9.96976	5	9.58719	38	10.41281	52
9	9.55728	33	9.96971	5	9.58757	37	10.41243	51
10	9.55761	32	9.96966	4	9.58794	38	10.41206	50
11	9.55793	33	9.96962	5	9.58832	37	10.41168	49
12	9.55826	32	9.96957	5	9.58869	38	10.41131	48
13	9.55858	33	9.96952	3	9.58907	37	10.41093	47
14	9.55891	32	9.96947	5	9.58944	37	10.41056	46
15	9.55923	33	9.96942	5	9.58981	38	10.41019	45
16	9.55956	32	9.96937	5	9.59019	37	10.40981	44
17	9.55988	33	9.96932	5	9.59056	38	10.40944	43
18	9.56021	32	9.96927	5	9.59094	37	10.40906	42
19	9.56053	32	9.96922	5	9.59131	37	10.40869	41
20	9.56085	33	9.96917	5	9.59168	37	10.40832	40
21	9.56118	32	9.96912	5	9.59205	38	10.40795	39
22	9.56150	32	9.96907	4	9.59243	37	10.40757	38
23	9.56182	33	9.96903	5	9.59280	37	10.40720	37
24	9.56215	32	9.96898	5	9.59317	37	10.40683	36
25	9.56247	32	9.96893	5	9.59354	37	10.40646	35
26	9.56279	32	9.96888	5	9.59391	38	10.40609	34
27	9.56311	32	9.96883	5	9.59429	37	10.40571	33
28	9.56343	32	9.96878	5	9.59466	37	10.40534	32
29	9.56375	33	9.96873	5	9.59503	37	10.40497	31
30	9.56408	32	9.96868	5	9.59540	37	10.40460	30
31	9.56440	32	9.96863	5	9.59577	37	10.40423	29
32	9.56472	32	9.96858	5	9.59614	37	10.40386	28
33	9.56504	32	9.96853	5	9.59651	37	10.40349	27
34	9.56536	32	9.96848	5	9.59688	37	10.40312	26
35	9.56568	31	9.96843	5	9.59725	37	10.40275	25
36	9.56599	32	9.96838	5	9.59762	37	10.40238	24
37	9.56631	32	9.96833	5	9.59799	36	10.40201	23
38	9.56663	32	9.96828	5	9.59835	37	10.40165	22
39	9.56695	32	9.96823	5	9.59872	37	10.40128	21
40	9.56727	32	9.96818	5	9.59909	37	10.40091	20
41	9.56759	31	9.96813	5	9.59946	37	10.40054	19
42	9.56790	32	9.96808	5	9.59983	36	10.40017	18
43	9.56822	32	9.96803	5	9.60019	37	10.39981	17
44	9.56854	32	9.96798	5	9.60056	37	10.39944	16
45	9.56886	31	9.96793	5	9.60093	37	10.39907	15
46	9.56917	32	9.96788	5	9.60130	36	10.39870	14
47	9.56949	31	9.96783	5	9.60166	37	10.39834	13
48	9.56980	32	9.96778	6	9.60203	37	10.39797	12
49	9.57012	32	9.96772	5	9.60240	36	10.39760	11
50	9.57044	31	9.96767	5	9.60276	37	10.39724	10
51	9.57075	32	9.96762	5	9.60313	36	10.39687	9
52	9.57107	31	9.96757	5	9.60349	37	10.39651	8
53	9.57138	31	9.96752	5	9.60386	36	10.39614	7
54	9.57169	32	9.96747	5	9.60422	37	10.39578	6
55	9.57201	31	9.96742	5	9.60459	36	10.39541	5
56	9.57232	32	9.96737	5	9.60495	37	10.39505	4
57	9.57264	31	9.96732	5	9.60532	36	10.39468	3
58	9.57295	31	9.96727	5	9.60568	37	10.89432	2
59	9.57326	32	9.96722	5	9.60605	36	10.39395	1
60	9.57358		9.96717		9.60641		10.39359	0
	Cos.		Sin		Cot		Tang.	

68 Degrees.

LOGARITHMIC SINES AND TANGENTS.

22 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.57358	31	9 96717	6	9.60641	36	10.39359	6
1	9.57389	31	9.96711	5	9.60677	37	10.39323	59
2	9.57420	31	9.96706	5	9.60714	36	10.39286	56
3	9.57451	31	9.96701	5	9.60750	36	10.39250	57
4	9.57482	32	9.96696	5	9.60786	37	10.39214	56
5	9.57514	31	9.96691	5	9.60823	36	10.39177	55
6	9.57545	31	9 96686	5	9.60859	36	10.39141	54
7	9.57576	31	9.96681	5	9.60895	36	10.39105	53
8	9.57607	31	9.96676	6	9.60931	36	10.39069	52
9	9.57638	31	9.96670	5	9.60967	37	10.39033	51
10	9.57669	31	9.96665	5	9.61004	36	10.38996	50
11	9.57700	31	9.96660	5	9.61040	36	10.38960	49
12	9 57731	31	9.96665	5	9.61076	36	10.38924	48
13	9 57762	31	9.96650	5	9.61112	36	10.38888	47
14	9.57793	31	9.96645	5	9.61148	36	10.38852	46
15	9.57824	31	9.96640	6	9.61184	36	10.38816	45
16	9.57855	30	9.96634	5	9.61220	36	10.38780	44
17	9.57885	31	9.96629	5	9.61256	36	10.38744	43
18	9.57916	31	9.96624	5	9.61292	36	10.38708	42
19	9.57947	31	9.96619	5	9.61328	36	10.38672	41
20	9.57978	30	9.96614	6	9.61364	36	10.38636	40
21	9.58008	31	9.96608	5	9.61404	36	10.38600	39
22	9.58039	31	9.96603	5	9.61436	36	10.38564	38
23	9.58070	31	9.96598	5	9.61472	36	10.38528	37
24	9.58141	30	9.96593	5	9.61508	36	10.38492	36
25	9 58131	31	9.96588	6	9.61544	35	10.38456	35
26	9.58162	30	9.96582	5	9.61579	36	10.38421	34
27	9.58192	31	9.96577	5	9.61615	36	10.38385	33
28	9.58223	30	9.96572	5	9.61651	36	10.38349	32
29	9.58253	31	9.96567	5	9.61687	35	10.38313	31
30	9.58284	30	9.96562	6	9.61722	36	10.38278	30
31	9 58314	31	9.96556	5	9.61758	36	10.38242	29
32	9.58345	30	9.96551	5	9.61794	36	10.38206	28
33	9.58375	31	9.96546	5	9.61830	35	10.38170	27
34	9.58406	30	9.96541	6	9.61865	36	10.38135	26
35	9.58436	31	9.96535	5	9.61901	35	10.38099	25
36	9.58467	30	9.96530	5	9.61936	36	10.38064	24
37	9.58497	30	9.96525	5	9.61972	36	10.38028	23
38	9.58527	30	9.96520	6	9.62008	35	10.37992	22
39	9.58557	31	9.96514	5	9.62043	36	10.37957	21
40	9.58588	30	9.96509	5	9.52079	35	10.37921	20
41	9 58618	30	9.96504	6	9.62114	36	10.37886	19
42	9.58648	30	9.96498	5	9.62150	35	10.37850	18
43	9.58678	31	9.96493	5	9.62185	36	10.37815	17
44	9.58709	30	9.96488	5	9.62221	35	10.37779	16
45	9 58739	30	9.96483	6	9.62256	36	10.37744	15
46	9.58769	30	9.96477	5	9.62292	35	10.37708	14
47	9.58799	30	9.96472	5	9.62327	35	10.37673	13
48	9.58829	30	9.96467	6	9.62362	36	10.37639	12
49	9.58859	30	9.96461	5	9.62398	35	10.37602	11
50	9 58889	30	9.96456	5	9.62433	35	10.37567	10
51	9.58919	30	9.96451	6	9.62468	36	10.37532	9
52	9.58949	30	9.96445	5	9.62504	35	10.37496	8
53	9.58978	30	9.96440	5	9.62539	35	10.37461	7
54	9 59009	30	9.96435	6	9.62574	35	10.37426	6
55	9.59039	[illegible]	9.96429	5	9.62609	36	10.37391	5
56	9.59068	29	9.96424	5	9.62645	35	10.37355	4
57	9.59098	30	9.96419	6	9.62680	35	10.37320	3
58	9.59128	30	9.96413	5	9.62715	35	10.37285	2
59	9.59158	30	9.96408	5	9.62750	35	10.37250	1
60	9.59188		9.96403		9.62785		10.37215	0
	Cos.		Sin		Cot		Tang	

67 Degrees.

23 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D	Cot.	′
0	9.59188	30	9.96403	6	9.62785	35	10.37215	60
1	9.59218	29	9.96397	5	9.62820	35	10 37180	59
2	9.59247	30	9.96392	5	9.62855	35	10.37145	58
3	9.59277	30	9.96387	6	9.62890	36	10.37110	57
4	9.59307	29	9.96381	5	9.62926	35	10.37074	56
5	9.59336	30	9.96376	6	9.62961	35	10.37039	55
6	9.59366	30	9.96370	5	9.62996	35	10.37004	54
7	9.59396	29	9.96365	5	9.63031	35	10.36969	53
8	9.59425	30	9.96360	6	9.63066	35	10.36934	52
9	9.59455	29	9.96354	5	9.63101	34	10.36899	51
10	9.59485	30	9.96349	6	9.63135	35	10.36865	50
11	9.59514	29	9.96343	5	9.63170	35	10.36830	49
12	9.59543	30	9.96338	5	9.63205	35	10.36795	48
13	9.59573	29	9.96333	6	9.63240	35	10.36760	47
14	9.59602	30	9.96327	5	9.63275	35	10.36725	46
15	9.59632	29	9.96322	6	9.63310	35	10.36690	45
16	9.59661	29	9.96316	5	9.63345	34	10.36655	44
17	9.59690	30	9.96311	6	9.63379	35	10.36621	43
18	9.59720	29	9.96305	5	9.63414	35	10.36586	42
19	9.59749	29	9.96300	6	9.63449	35	10.36551	41
20	9.59778	30	9 96294	5	9.63484	35	10.36516	40
21	9.59808	29	9.96289	5	9.63519	34	10.36481	39
22	9.59837	29	9.96284	6	9.63553	35	10.36447	38
23	9.59866	29	9.96278	5	9.63588	35	10.36412	37
24	9.59895	29	9.96273	6	9.63623	34	10.36377	36
25	9.59924	30	9.96267	5	9.63657	35	10.36343	35
26	9.59954	29	9.96262	6	9.63692	34	10.36308	34
27	9.59983	29	9.96256	5	9 63726	35	10.36274	33
28	9.60012	29	9.96251	6	9.63761	35	10.36239	32
29	9.60041	29	9.96245	5	9.63796	34	10.36204	31
30	9.60070	29	9.96240	6	9.63830	35	10.36170	30
31	9.60099	29	9.96234	5	9.63865	34	10.36135	29
32	9.60128	29	9.96229	6	9.63899	35	10.36101	28
33	9.60157	29	9.96223	5	9.63934	34	10.36066	27
34	9.60186	29	9.96218	6	9.63968	35	10.36032	26
35	9.60215	29	9.96212	5	9.64003	34	10.35997	25
36	9.60244	29	9.96207	6	9.64037	35	10.35963	24
37	9.60273	29	9.96201	5	9.64072	34	10.35928	23
38	9.60302	29	9.96196	6	9.64106	34	10.35894	22
39	9.60331	28	9.96190	5	9.64140	35	10.35860	21
40	9.60359	29	9.96185	6	9.64175	34	10.35825	20
41	9.60388	29	9.96179	5	9.64209	34	10.35791	19
42	9.60417	29	9.96174	6	9.64243	35	10 35757	18
43	9.60446	28	9.96168	5	9 64278	34	10.35722	17
44	9.60474	29	9.96162	6	9.64312	34	10.35688	16
45	9.60503	29	9.96157	6	9.64346	35	10.35654	15
46	9.60532	29	9.96151	5	9.64381	34	10.35619	14
47	9.60561	28	9.96146	6	9.64415	34	10.35585	13
48	9.60589	29	9.96140	5	9.64449	34	10.35551	12
49	9.60618	28	9.96135	6	9.64483	34	10.35517	11
50	9.60646	29	9.96129	6	9.64517	35	10.35483	10
51	9.60675	29	9 96123	5	9.64552	34	10.35448	9
52	9.60704	28	9.96118	6	9.64586	34	10 35414	8
53	9.60732	29	9.96112	5	9.64620	34	10.35380	7
54	9.60761	28	9.96107	6	9.64654	34	10.35346	6
55	9.60789	29	9.96101	6	9.64688	34	10.35312	5
56	9.60818	28	9.96095	5	9.64722	34	10.35278	4
57	9.60846	29	9.96090	6	9.64756	34	10.35244	3
58	9.60875	28	9.96084	5	9 64790	34	10.35210	2
59	9.60903	28	9.96079	6	9.64824	34	10.35176	1
60	9.60931		9.96073		9.64858		10.35142	0
	Cos.		Sin.		Cot.		Tang.	

66 Degrees.

LOGARITHMIC SINES AND TANGENTS.

24 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.60931	29	9.96073	6	9.64858	34	10.35142	60
1	9.60960	28	9.96067	5	9.64892	34	10.35108	59
2	9.60988	28	9.96062	6	9.64926	34	10.35074	58
3	9.61016	29	9.96056	6	9.64960	34	10.35040	57
4	9.61045	28	9.96050	5	9.64904	34	10 35006	56
5	9.61073	28	9.96045	6	9.65028	34	10.34972	55
6	9.61101	28	9.96039	5	9.65062	34	10.34938	54
7	9.61129	29	9.96034	6	9.65096	34	10.34904	53
8	9.61158	28	9.96028	6	9.65130	34	10.34870	52
9	9.61186	28	9.96022	5	9.65164	33	10.34836	51
10	9 61214	28	9.96017	6	9 65197	34	10.34803	50
11	9.61242	28	9.96011	6	9 65231	34	10.34769	49
12	9 61270	28	9.96005	5	9.65265	34	10.34735	48
13	9.61298	28	9.96000	6	9 65299	34	10.34701	47
14	9.61326	28	9.95994	6	9.65333	33	10 34667	46
15	9.61354	28	9.95988	6	9.65366	34	10.34634	45
16	9.61382	29	9.95982	5	9.65400	34	10.34600	44
17	9 61411	27	9.95977	6	9.65434	53	10.34566	43
18	9.61438	28	9.95971	6	9.65467	34	10.34533	42
19	9.61466	28	9.95965	5	9.65501	34	10.34499	41
20	9.61494	28	9.95960	6	9.65535	33	10.34465	40
21	9.61522	28	9.95954	6	9.65568	34	10.34422	39
22	9.61550	28	9.95948	6	9.65602	34	10.34398	38
23	9.61578	28	9.95942	5	9.65636	33	10.34364	37
24	9.61606	28	9.95937	6	9.65669	34	10.34331	36
25	9 61634	28	9.95931	6	9.65703	33	10.34297	35
26	9.61662	27	9.95925	5	9.65736	34	10.34264	34
27	9.61689	28	9.95920	6	9.65770	33	10.34280	33
28	9.61717	28	9.95914	6	9.65803	34	10.34197	32
29	9.61745	28	9.95908	6	9.65837	33	10.34163	31
30	9 61773	27	9.95902	5	9.65870	34	10.34130	30
31	9.61800	28	9.95897	6	9.65904	33	10·34096	29
32	9.61828	28	9.95891	6	9.65937	34	10.34063	28
33	9.61856	27	9 95885	6	9.65971	33	10.34029	27
34	9.61883	28	9.95879	6	9.66004	34	10.33996	26
35	9.61911	28	9.95873	5	9.66038	33	10.33962	25
36	9.61939	27	9.95868	6	9.66071	33	10.33929	24
37	9.61966	28	9.95862	6	9.66104	34	10.33896	23
38	9.61994	27	9.95856	6	9.66138	33	10.33862	22
39	9.62021	28	9.95850	6	9.66171	33	10 33829	21
40	9 62049	27	9.95844	5	9.66204	34	10.33796	20
41	9 62076	28	9.95839	6	9.66238	33	10.33762	19
42	9.62104	27	9.95833	6	9.66271	33	10.33729	18
43	9.62131	28	9 95827	6	9.66304	33	10.33696	17
44	9.62159	27	9 95821	6	9.66337	34	10.33663	16
45	9.62186	28	9.95815	5	9 66371	33	10.33629	15
46	9.62214	27	9.95810	6	9.66404	33	10.33596	14
47	9.62241	27	9.95804	6	9.66437	33	10.33563	13
48	9.62268	28	9 95798	6	9.66470	33	10 33530	12
49	9.62296	27	9.95792	6	9.66503	34	10.33497	11
50	9 62323	27	9.95786	6	9.66537	35	10.33463	10
51	9.62350	27	9.95780	5	9.66570	33	10.33430	9
52	9.62377	28	9.95775	6	9.66603	33	10.33397	8
53	9.62405	27	9.95769	6	9.66636	33	10.33364	7
54	9.62430	27	9.95763	6	9.66669	83	10.33331	6
55	9.62459	27	9.95757	6	9.66702	33	10.33298	5
56	9 62486	27	9.95751	6	9.66735	33	10.33265	4
57	9.62513	28	9.95745	6	9.66768	33	10.33232	3
58	9.62541	27	9.95739	6	9.66801	33	10.33199	2
59	9.62568	27	9.95733	5	9.66834	33	10.33166	1
60	9 62595		9.95728		9.66867		10.33133	0
	Cos.		Sin.		Cot.		Tang.	

65 Degrees.

25 Degrees.

′	Sin.	D	Cos.	D.	Tang	D.	Cot.	′
0	9.62595	27	9.95728	6	9.66867	33	10.33133	60
1	9.62622	27	9.95722	6	9.66900	33	10.33100	59
2	9.62649	27	9.95716	6	9.66933	33	10.33067	58
3	9.62676	27	9.95710	6	9.66966	33	10.33034	57
4	9 62703	27	9.95704	6	9.66999	33	10.33001	56
5	9.62730	27	9.95698	6	9.67032	33	10 32968	55
6	9.62757	27	9.95692	6	9 67065	33	10.32935	54
7	9.62784	27	9.95686	6	9.67098	33	10.32902	53
8	9.62811	27	9.95680	6	9.67131	32	10 32869	52
9	9.62838	27	9.95674	6	9.67163	33	10 32837	51
10	9.52865	27	9.95668	5	9.67196	33	10.32804	50
11	9.62892	26	9.95663	6	9.67229	33	10 32771	49
12	9 62918	27	9.95657	6	9.67262	33	10.32738	48
13	9.62945	27	9.95651	6	9.67295	32	10 32705	47
14	9 62972	27	9.95645	6	9.67327	33	10.32673	46
15	9.62999	27	9.95639	6	9.67360	33	10 32640	45
16	9.63026	26	9.95633	6	9.67393	33	10.32607	44
17	9.63052	27	9.95627	6	9.67426	32	10.32574	43
18	9 63079	27	9.95621	6	9.67458	33	10.32542	42
19	9.63106	27	9.95615	6	9.67491	33	10.32509	41
20	9.63133	26	9.95609	6	9.67524	32	10.32476	40
21	9.63159	27	9.95603	6	9.67556	33	10.32444	39
22	9.63186	27	9.95597	6	9.67589	33	10.32411	38
23	9.63213	26	9 95591	6	9.67622	32	10.32378	37
24	9.63239	27	9.95585	6	9.67654	33	10.32346	36
25	9.63266	26	9.95589	6	9.67687	32	10 32313	35
26	9 63292	27	9.95573	6	9.67719	33	10.32281	34
27	9.63319	26	9.95567	6	9.67752	33	10.32248	33
28	9.63345	27	9.95561	6	9.67785	32	10.32215	32
29	9.63372	26	9.95555	6	9.67817	33	10 32183	31
30	9.63398	27	9 95549	6	9.67850	32	10.32150	30
31	9.63425	26	9.95543	6	9.67882	33	10.32118	29
32	9.63451	27	9.95537	6	9.67915	32	10.32085	28
33	9.63478	26	9.95531	6	9.67947	33	10 32053	27
34	9 63504	27	9.95525	6	9.67980	32	10.32020	26
35	9.63531	26	9.95519	6	9.68012	32	10.31988	25
36	9.63557	26	9.95513	6	9.68044	33	10.31956	24
37	9.63583	27	9.95507	7	9.68077	32	10.31923	23
38	9.63610	26	9.95500	6	9.68109	33	10.31891	22
39	9 63636	26	9.95494	6	9.68142	32	10.31858	21
40	9.63662	27	9.95488	6	9 68174	32	10 31826	20
41	9 63689	26	9.95482	6	9.68206	33	10.31794	19
42	9.63715	26	9.95476	6	9.68239	32	10.31761	18
43	9.63741	26	9.95470	6	9 68271	32	10.31729	17
44	9.63767	27	9.95464	6	9.68303	33	10.31697	16
45	9 63794	26	9.95458	6	9 68336	32	10.31664	15
46	9.63820	26	9.95452	6	9 68368	32	10.31632	14
47	9.63846	26	9 95446	6	9.68400	32	10.31600	13
48	9.63872	26	9.95440	6	9.68432	33	10.31568	12
49	9.63898	26	9.95434	7	9.68465	32	10.31535	11
50	9.63924	26	9.95427	6	9.68497	32	10.31503	10
51	9.63950	26	9.95421	6	9.68529	32	10.31471	9
52	9.63976	26	9.95415	6	9.68561	32	10.31439	8
53	9.64002	26	9.95409	6	9.68593	33	10.31407	7
54	9.64028	26	9.95403	6	9.68626	32	10.31374	6
55	9.64054	26	9.95397	6	9.68658	32	10 31342	5
56	9.64080	26	9.95391	7	9.68690	32	10.31310	4
57	9.64106	26	9.95384	6	9.68722	32	10 31278	3
58	9.64132	26	9.95378	6	9.68754	32	10.31246	2
59	9.64158	26	9.95572	6	9 68786	32	10.31214	1
60	9 64184		9.95366		9.68818		10.31182	0
	Cos.		Sin.		Cot.		Tang.	

64 Degrees.

LOGARITHMIC SINES AND TANGENTS.

26 Degrees.

′	Sin.	D.	Cos.	D	Tang.	D.	Cot.	′
0	9.64184	26	9.95366	6	9.68818	32	10.31182	60
1	9.64210	26	9.95360	6	9.68850	32	10.31150	59
2	9.64236	26	9.95354	6	9.68882	32	10.31118	58
3	9.64262	26	9.95348	7	9.68914	32	10.31086	57
4	9.64288	25	9.95341	6	9.68946	32	10.31054	56
5	9.64313	26	9.95335	6	9.68978	32	10.31022	55
6	9.64339	26	9.95329	6	9.69010	32	10.30990	54
7	9.64365	26	9 95323	6	9.69042	32	10.30958	53
8	9.64391	26	9.95317	7	9.69074	32	10.30926	52
9	9.64417	25	9.95310	6	9.69106	32	10.30894	51
10	9.64442	26	9.95304	6	9.69138	32	10 30862	50
11	9.64468	26	9.95298	6	9.69170	32	10.30830	49
12	9.64494	25	9.95292	6	9.69202	32	10.30798	48
13	9.64519	26	9.95286	7	9.69234	32	10.30766	47
14	9.64545	26	9.95279	6	9.69266	32	10.30734	46
15	9.64571	25	9.95273	6	9.69298	31	10 30702	45
16	9.64596	26	9.95267	6	9.69329	32	10.30671	44
17	9.64622	25	9.95261	7	9.69361	32	10.30639	43
18	9.64647	26	9.95254	6	9.69393	32	10.30607	42
19	9.64673	25	9.95248	5	9.69425	32	10.30575	41
20	9.64698	26	9.95242	6	9.69457	31	10 30543	40
21	9.64724	25	9.95236	7	9.69488	32	10.30512	39
22	9.64749	26	9.95229	6	9.69520	32	10.30480	38
23	9.64775	25	9 95223	6	9.69552	32	10.30448	37
24	9.64800	26	9 95217	6	9.69584	31	10.30416	36
25	9.64826	25	9.95211	7	9.69615	32	10.30385	35
26	9.64851	26	9.95204	6	9.69647	32	10.30353	34
27	9.64877	25	9.95198	6	9.69679	32	10.30321	33
28	9.64902	25	9.95192	7	9.69710	32	10.30290	32
29	9.64927	26	9.95185	6	9.69742	32	10.30258	31
30	9.64953	25	9.95179	6	9.69774	31	10.30226	30
31	9.64978	25	9 95173	6	9.69805	32	10.30195	29
32	9.65003	26	9 95167	7	9.69837	31	10.30163	28
33	9.65029	25	9.9516	6	9.69868	32	10.30132	27
34	9.65054	25	9.95154	6	9.69900	32	10.30100	26
35	9.65079	25	9.95148	7	9 69932	31	10.30068	25
36	9.65104	26	9.95141	6	9.69963	32	10.30037	24
37	9.65130	25	9 95135	6	9.69995	31	10.30005	23
38	9.65155	25	9.95129	7	9 70026	32	10.29974	22
39	9.65180	25	9.95122	6	9.70058	31	10.29942	21
40	9.65305	25	9.95116	6	9.70089	32	10.29911	20
41	9.65230	25	9.95110	7	9.70121	31	10.29879	19
42	9.65255	26	9.95103	6	9.70152	32	10.29848	18
43	9.65281	25	9.95097	7	9.70184	31	10.29816	17
44	9.65306	25	9.95090	6	9.70215	32	10.29785	16
45	9.65331	25	9.95084	6	9.70247	31	10.29753	15
46	9.65356	25	9.95078	7	9.70278	31	10.29722	14
47	9.65381	25	9.95071	6	9.70309	32	10 29691	13
48	9.65406	25	9 95065	6	9.70341	31	10 29659	12
49	9.65431	25	9.95059	7	9.70372	32	10.29628	11
50	9.65456	25	9 95052	6	9.70404	31	10.29596	10
51	9.65481	25	9.95046	7	9.70435	31	10.29565	9
52	9.65506	25	9 95039	6	9.70466	32	10.29534	8
53	9.65532	25	9.95033	6	9.70498	31	10.29502	7
54	9.65556	24	9.95027	7	9.70529	31	10.29471	6
55	9.65580	25	9.95020	6	9.70560	32	10.29440	5
56	9.65605	25	9.95014	7	9.70592	31	10.29408	4
57	9.65630	25	9.95007	6	9 70623	31	10.29377	3
58	9.65655	25	9.95001	6	9 70654	31	10.29346	2
59	9.65680	25	9.95995	7	9.70685	32	10.29315	1
60	9.65705		9.95988		9.70717		10.29283	0
	Cos.		Sin.		Cot.		Tang.	

63 Degrees.

27 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.65705	24	9.94988	6	9.70717	31	10.29283	60
1	9.65729	25	9.94982	7	9.70748	31	10.29252	59
2	9.65754	25	9.94975	6	9.70779	31	10.29221	58
3	9.65779	25	9.94960	7	9.70810	31	10.29190	57
4	9.65804	24	9.94962	6	9.70841	32	10.29159	56
5	9.65828	25	9.94956	7	9.70873	31	10.29127	55
6	9.65853	25	9.94949	6	9.70904	31	10.29096	54
7	9.65878	24	9.94943	7	9.70935	31	10.29065	53
8	9.65902	25	9.94936	6	9.70966	31	10.29034	52
9	9.65927	25	9.94930	7	9 70997	31	10.29003	51
10	9.65952	24	9.94923	6	9.71028	31	10.28972	50
11	9.65976	25	9 94917	6	9.71059	31	10.28941	49
12	9.66001	24	9.94911	7	9.71090	31	10.28910	48
13	9.66025	25	9.94904	6	9.71121	32	10.28879	47
14	9.66050	25	9.94898	7	9.71153	31	10.28847	46
15	9.66075	24	9.94891	6	9.71184	31	10 28816	45
16	9.66099	25	9.94885	7	9.71215	31	10.28785	44
17	9.66124	24	9.94878	7	9.71246	31	10.28754	43
18	9.66148	25	9.94871	6	9.71277	31	10.28723	42
19	9.66173	24	9.94865	7	9.71308	31	10.28692	41
20	9.66197	24	9.94858	6	9.71339	31	10.28661	40
21	9.66221	25	9.94852	7	9.71370	31	10.28630	39
22	9.66246	24	9.94845	6	9.71401	30	10 28599	38
23	9.66270	25	9.94839	7	9 71431	31	10.28569	37
24	9.66295	24	9.94832	6	9.71462	31	10.28538	36
25	9.66319	24	9.94826	7	9 71493	31	10 28507	35
26	9.66343	25	9.94819	6	9.71524	31	10.28476	34
27	9.66368	24	9.94813	7	9.71555	31	10.28445	33
28	9.66392	24	9.94806	7	9.71586	31	10.28414	32
29	9.66416	25	9.94799	6	9 71617	31	10.28383	31
30	9.66441	24	9.94793	7	9.71648	31	10.28352	30
31	9.66465	24	9.94786	6	9.71679	30	10.28321	29
32	9.66489	24	9.94780	7	9.71709	31	10.28291	28
33	9.66513	24	9.94773	6	9.71740	31	10.28260	27
34	9.66537	25	9.94767	7	9.71771	31	10.28229	26
35	9.66562	24	9 94770	7	9.71802	31	10.28198	25
36	9.66586	24	9.94753	6	9.71833	30	10.28167	24
37	9.66610	24	9.94747	7	9.71863	31	10.28137	23
38	9.66634	24	9.94740	6	9.71894	31	10.28106	22
39	9 66658	24	9.94734	7	9.71925	30	10.28075	21
40	9 66682	24	9.94727	7	9.71955	31	10.28045	20
41	9.66706	25	9.94720	6	9.71986	31	10.28014	19
42	9.66731	24	9.94714	7	9.72017	31	10.27983	18
43	9.66755	24	9.94707	7	9.72048	30	10.27952	17
44	9.66779	24	9.94700	6	9.72078	31	10.27922	16
45	9.66803	24	9.94694	7	9.72109	31	10.27891	15
46	9.66827	24	9.94687	7	9.72140	30	10.27860	14
47	9.66851	24	9.94680	6	9.72170	31	10.27830	13
48	9.66875	24	9.94674	7	9.72201	30	10.27799	12
49	9.66899	23	9.94667	7	9.72231	31	10.27769	11
50	9.66922	24	9.94660	6	9.72262	31	10.27738	10
51	9.66946	24	9.94654	7	9.72293	30	10.27707	9
52	9.66970	24	9.94647	7	9.72323	31	10.27677	8
53	9.66994	24	9.94640	6	9.72354	30	10.27646	7
54	9.67018	24	9.94634	7	9.72384	31	10.27616	6
55	9.67042	24	9.94627	7	9.72415	30	10.27585	5
56	9 67066	24	9.94620	6	9.72445	31	10.27555	4
57	9.67090	23	9.94614	7	9.72476	30	10.27524	3
58	9.67113	24	9.94607	7	9.72506	31	10.27494	2
59	9.67137	24	9.94600	7	9 72537	30	10 27463	1
60	9.67161		9.94593		9.72567		10.27433	0
	Cos.		Sin.		Cot.		Tang.	

62 Degrees.

LOGARITHMIC SINES AND TANGENTS.

26 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.67161	24	9.94593	6	9.72567	31	10.27433	60
1	9.67185	23	9.94587	7	9.72598	30	10.27402	59
2	9.67208	24	9.94580	7	9.72628	31	10.27372	58
3	9.67232	24	9.94573	6	9.72659	30	10.27341	57
4	9.67256	24	9.94567	7	9.72689	31	10.27311	56
5	9.67280	23	9.94560	7	9.72720	30	10.27280	55
6	9.67303	24	9.94553	7	9.72750	30	10.27250	54
7	9.67327	23	9.94546	6	9.72780	31	10.27220	53
8	9.67350	24	9.94540	7	9.72811	30	10.27189	52
9	9.67374	24	9.94533	7	9.72841	31	10.27159	51
10	9.67398	23	9.94526	7	9.72872	30	10.27128	50
11	9.67421	24	9.94519	6	9.72902	30	10.27098	49
12	9.67445	23	9.94513	7	9.72932	31	10.27068	48
13	9.67468	24	9.94506	7	9.72963	30	10.27037	47
14	9.67492	23	9.94499	7	9.72993	30	10.27007	46
15	9.67515	24	9.94492	7	9.73023	31	10.26977	45
16	9.67539	23	9.94485	6	9.73054	30	10.26946	44
17	9.67562	24	9.94479	7	9.73084	30	10.26916	43
18	9.67596	23	9.94472	7	9.73114	30	10.26886	42
19	9.67609	24	9.94465	7	9.73144	31	10.26856	41
20	9.67633	23	9.94458	7	9.73175	30	10.26825	40
21	9.67656	24	9.94451	6	9.73205	30	10.26795	39
22	9.67680	23	9.94445	7	9.73235	30	10.26765	38
23	9.67703	23	9.94438	7	9.73265	30	10.26735	37
24	9.67726	24	9.94431	7	9.73295	31	10.26705	36
25	9.67750	23	9.94424	7	9.73326	30	10.26674	35
26	9.67773	23	9.94417	7	9.73356	30	10.26644	34
27	9.67796	24	9.94410	6	9.73386	30	10.26614	33
28	9.67820	23	9.94404	7	9.73416	30	10.26584	32
29	9.67843	23	9.94397	7	9.73446	30	10.26554	31
30	9.67866	24	9.94390	7	9.73476	31	10.26524	30
31	9.67890	23	9.94383	7	9.73507	30	10.26493	29
32	9.67913	23	9.94376	7	9.73537	30	10.26463	28
33	9.67936	23	9.94369	7	9.73567	30	10.26433	27
34	9.67959	23	9.94362	7	9.73597	30	10.26403	26
35	9.67982	24	9.94355	6	9.73627	30	10.26373	25
36	9.68006	23	9.94349	7	9.73657	30	10.26343	24
37	9.68029	23	9.94342	7	9.73687	30	10.26313	23
38	9.68052	23	9.94335	7	9.73717	30	10.26283	22
39	9.68075	23	9.94328	7	9.73747	30	10.26253	21
40	9.68098	23	9.94321	7	9.73777	30	10.26223	20
41	9.68121	23	9.94314	7	9.73807	30	10.26193	19
42	9.68144	23	9.94307	7	9.73837	30	10.26163	18
43	9.68167	23	9.94300	7	9.73867	30	10.26133	17
44	9.68190	23	9.94293	7	9.73897	30	10.26103	16
45	9.68213	24	9.94286	7	9.73927	30	10.26073	15
46	9.68237	23	9.94279	6	9.73957	30	10.26043	14
47	9.68260	23	9.94273	7	9.73987	30	10.26013	13
48	9.68283	23	9.94266	7	9.74017	30	10.25983	12
49	9.68305	23	9.94259	7	9.74047	30	10.25953	11
50	9.68328	23	9.94252	7	9.74077	30	10.25923	10
51	9.68351	23	9.94245	7	9.74107	30	10.25893	9
52	9.68374	23	9.94238	7	9.74137	29	10.25863	8
53	9.68397	23	9.94231	7	9.74166	30	10.25834	7
54	9.68420	23	9.94224	7	9.74196	30	10.25804	6
55	9.68443	23	9.94217	7	9.74226	30	10.25774	5
56	9.68466	23	9.94210	7	9.74256	30	10.25744	4
57	9.68489	23	9.94203	7	9.74286	30	10.25714	3
58	9.68512	23	9.94196	7	9.74316	29	10.25684	2
59	9.68534	23	9.94189	7	9.74345	30	10.25655	1
60	9.68557		9.94182		9.74375		10.25625	0
	Cos.		Sin.		Cot.		Tang.	

59 Degrees.

29 Degrees.

′	Sin.	D.	Cos.	D	Tang.	D.	Cot.	′
0	9.68557	23	9.94182	7	9.74375	30	10.25625	60
1	9.68580	23	9.94175	7	9.74405	30	10.25595	59
2	9.68603	22	9.94168	7	9.74435	30	10.25565	58
3	9.68625	23	9.94161	7	9.74465	29	10.25535	57
4	9.68648	23	9.94154	7	9.74494	30	10.25506	56
5	9.68671	23	9.94147	7	9.74524	30	10.25476	55
6	9.68694	22	9.94140	7	9.74554	29	10.25446	54
7	9.68716	23	9.94133	7	9.74583	30	10.25417	53
8	9.68739	23	9.94126	7	9.74613	30	10.25387	52
9	9.68762	22	9.94119	7	9.74643	30	10.25357	51
10	9.68784	23	9.94112	7	9.74673	29	10.25327	50
11	9.68807	22	9.94105	7	9.74702	30	10.25298	49
12	9.68829	23	9.94098	8	9.74732	30	10.25268	48
13	9.68852	23	9.94090	7	9.74762	29	10.25238	47
14	9.68875	22	9.94083	7	9.74791	30	10.25209	46
15	9.68897	23	9.94076	7	9.74821	30	10.25179	45
16	9.68920	22	9.94069	7	9.74851	29	10.25149	44
17	9.68942	23	9.94062	7	9.74880	30	10.25120	43
18	9.68965	22	9.94055	7	9.74910	29	10.25090	42
	9.68987	23	9.94048	7	9.74939	30	10.25061	41
20	9.68010	22	9.94041	7	9.74969	29	10.25037	40
21	9.69032	23	9.94034	7	9.74998	30	10.25002	39
22	9.69055	22	9.94027	7	9.75028	30	10.24972	38
23	9.69077	23	9.94020	8	9.75058	29	10.24942	37
24	9.69100	22	9.94012	7	9.75087	30	10.24913	36
25	9.69122	22	9.94005	7	9.75117	29	10.24883	35
26	9.69144	23	9.93998	7	9.75146	30	10.24854	34
27	9.69167	22	9.93991	7	9.75176	29	10.24824	33
28	9.69189	23	9.93984	7	9.75205	30	10.24795	32
29	9.69212	22	9.93977	7	9.75235	29	10.24765	31
30	9.69234	22	9.93970	7	9.75264	30	10.24736	30
31	9.69256	23	9.93963	8	9.75294	29	10.24706	29
32	9.69279	22	9.93955	7	9.75323	30	10.24677	28
33	9.69301	22	9.93948	7	9.75353	29	10.24647	27
34	9.69323	22	9.93941	7	9.75382	29	10.24618	26
35	9.69345	23	9.93934	7	9.75411	30	10.24589	25
36	9.69368	22	9.93927	7	9.75441	29	10.24559	24
37	9.69390	22	9.93920	8	9.75470	30	10.24530	23
38	9.69412	22	9.93912	7	9.75500	29	10.24500	22
39	9.69434	22	9.93905	7	9.75529	29	10.24471	21
40	9.69456	23	9.93898	7	9.75558	30	10.24442	20
41	9.69479	22	9.93891	7	9.75588	29	10.24412	19
42	9.69501	22	9.93884	8	9.75617	30	10.24383	18
43	9.69523	22	9.93876	7	9.75647	29	10.24353	17
44	9.69545	22	9.93869	7	9.75676	29	10.24324	16
45	9.69567	22	9.93862	7	9.75707	30	10.24295	15
46	9.69589	22	9.93855	8	9.75735	29	10.24265	14
47	9.69611	22	9.93847	7	9.75764	29	10.24236	13
48	9.69633	22	9.93840	7	9.75793	29	10.24207	12
49	9.69655	22	9.93833	7	9.75822	30	10.24178	11
50	9.69677	22	9.93826	7	9.75852	29	10.24148	10
51	9.69699	22	9.93819	8	9.75881	29	10.24119	9
52	9.69721	22	9.93811	7	9.75910	29	10.24090	8
53	9.69743	22	9.93804	7	9.75939	30	10.24061	7
54	9.69765	22	9.93797	8	9.75969	29	10.24031	6
55	9.69787	22	9.93789	7	9.75998	29	10.24002	5
56	9.69809	22	9.93782	7	9.76027	29	10.23973	4
57	9.69831	22	9.93775	7	9.76056	30	10.23944	3
58	9.69853	22	9.93768	8	9.76086	29	10.23914	2
59	9.69875	22	9.93760	7	9.76115	29	10.23885	1
60	9.69897		9.93753		9.76144		10.23856	0
	Cos.		Sin.		Cot.		Tang.	

60 Degrees.

LOGARITHMIC SINES AND TANGENTS.

30 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.69897	22	9.93753	7	9.76144	29	10.23856	60
1	9.69919	22	9.93746	8	9.76173	29	10.23827	59
2	9.69941	22	9.93738	7	9.76202	29	10 23798	58
3	9.69963	21	9.93731	7	9.76231	30	10.23769	57
4	9.69984	22	9.93724	7	9.76261	29	10.23739	56
5	9.70006	22	9 93717	8	9 76290	29	10.23710	55
6	9.70028	22	9.93709	7	9.76319	29	10.23681	54
7	9.70050	22	9 93702	7	9.76348	29	10·23652	53
8	9.70072	21	9.93695	8	9.76377	29	10.23623	52
9	9.70093	22	9.93687	7	9.76406	29	10.23594	51
10	9.70115	22	9.93680	7	9.76435	29	10 23565	50
11	9.70137	22	9.93673	8	9.76464	29	10.23536	49
12	9.70159	21	9.93665	7	9.76493	29	10.23507	48
13	9.70180	22	9.93658	8	9.76522	29	10.23478	47
14	9.70202	22	9.93650	7	9.76551	29	10.23449	46
15	9.70224	21	9.93643	7	9.76580	29	10 23420	45
16	9.70245	22	9.93636	8	9.76609	30	10.23391	44
17	9.70267	21	9.93628	7	9.76639	29	10.23361	43
18	9.70288	22	9.93621	7	9.76668	29	10.23332	42
19	9.70310	22	9.93614	8	9.76697	28	10.23303	41
20	9.70332	21	9.93606	7	9.76725	29	10.23275	40
21	9.70353	22	9.93599	8	9.76754	29	10.23246	39
22	9.70375	21	9.93591	7	9.76783	29	10.23217	38
23	9.70396	22	9.93584	7	9.76812	29	10.23188	37
24	9.70418	21	9.93577	8	9.76841	29	10.23159	36
25	9.70439	22	9.93569	7	9.76870	29	10 23130	35
26	9.70461	21	9.93562	8	9.76899	29	10.23101	34
27	9.70482	22	9.93554	7	9.76928	29	10.23072	33
28	9.70504	21	9.93547	8	9.76957	29	10.23043	32
29	9.70525	22	9.93539	7	9.76986	29	10.23014	31
30	9.70547	21	9.93532	7	9.77015	29	10.22985	30
31	9.70568	22	9.93525	8	9.77044	29	10.22956	29
32	9.70590	21	9.93517	7	9.77073	28	10.22927	28
33	9.70611	22	9.93510	8	9.77101	29	10.22899	27
34	9.70633	21	9.93502	7	9.77130	29	10.22870	26
35	9.70654	21	9.93495	8	9 77159	29	10.22841	25
36	9.70675	22	9.93487	7	9.77188	29	10.22812	24
37	9.70697	21	9.93480	8	9.77217	29	10.22783	23
38	9.70718	21	9.93472	7	9.77246	28	10.22754	22
39	9.70739	22	9.93465	8	9.77274	29	10.22726	21
40	9.70761	21	9.93457	7	9.77303	29	10.22697	20
41	9.70782	21	9.93450	8	9.77332	29	10.22668	19
42	9.70803	21	9.93442	7	9.77361	29	10.22639	18
43	9.70824	22	9.93435	8	9.77390	28	10.22610	17
44	9.70846	21	9.93427	7	9.77418	29	10.22582	16
45	9.70867	21	9 93420	8	9.77447	29	10.22553	15
46	9.70888	21	9.93412	7	9 77476	29	10.22524	14
47	9.70909	22	9.93405	8	9.77505	28	10.22495	13
48	9.70931	21	9 93397	7	9.77533	29	10.22467	12
49	9.70952	21	9.93390	8	9.77562	29	10 22438	11
50	9.70973	21	9.93382	7	9.77591	28	10.22409	10
51	9.70994	21	9.93375	8	9.77619	29	10.22381	9
52	9.71015	21	9.93367	7	9.77648	29	10.22352	8
53	9.71036	22	9 93360	8	9.77677	29	10.22323	7
54	9.71058	21	9.93352	8	9.77706	28	10.22294	6
55	9.71079	21	9 93344	7	9.77734	29	10.22266	5
56	9.71100	21	9.93337	8	9.77763	28	10.22237	4
57	9.71121	21	9.93329	7	9 77791	29	10.22209	3
58	9.71142	21	9 93322	8	9 77820	29	10.22180	2
59	9.71163	21	9.93314	7	9.77849	28	10.22151	1
60	9.71184		9.93307		9.77877		10.22223	0
	Cos.		Sin.		Cot.		Tang.	

59 Degrees.

31 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.71184	21	9.93307	8	9.77877	29	10.22123	60
1	9.71205	21	9.93299	8	9.77906	29	10.22094	59
2	9.71226	21	9.93291	7	9.77935	28	10.22065	58
3	9.71247	21	9.93284	8	9.77963	29	10.22037	57
4	9.71268	21	9.93276	7	9.77992	28	10.22008	56
5	9.71289	21	9.93269	8	9.78020	29	10.21980	55
6	9.71310	21	9.93261	8	9.78049	28	10.21951	54
7	9.71331	21	9.93253	7	9.78077	29	10.21923	53
8	9.71352	21	9.93246	8	9.78106	29	10.21894	52
9	9.71373	20	9.93238	8	9.78135	28	10.21865	51
10	9 71393	21	9.93230	7	9.78163	29	10.21837	50
11	9.71414	21	9.93223	8	9.78192	28	10.21808	49
12	9.71435	21	9.93215	8	9.78220	29	10.21780	48
13	9.71456	21	9.93207	7	9.78249	28	10.21751	47
14	9.71477	21	9.93200	8	9.78277	29	10.21723	46
15	9.71498	21	9.93192	8	9.78306	28	10.21694	45
16	9.71519	20	9.93184	7	9.78334	29	10.21666	44
17	9.71539	21	9.93177	8	9.78363	28	10.21637	43
18	9.71560	21	9.93169	8	9.78391	28	10.21609	42
19	9.71581	21	9.93161	7	9.78419	29	10.21581	41
20	9 71602	20	9.93154	8	9.78448	28	10 21552	40
21	9.71622	21	9.93146	8	9.78476	29	10.21524	39
22	9.71643	21	9.93138	7	9.78505	28	10.21495	38
23	9.71664	21	9.93131	8	9.78533	29	10.21467	37
24	9.71685	20	9.93123	8	9.78562	28	10.21438	36
25	9.71705	21	9.93115	7	9.78590	28	10 21410	35
26	9.71726	21	9.93108	8	9.78618	29	10.21382	34
27	9.71747	20	9.93100	8	9.78647	28	10.21353	33
28	9 71767	21	9.93092	8	9.78675	29	10.21325	32
29	9.71788	21	9.93084	7	9.78704	28	10.21296	31
30	9.71809	20	9.93077	8	9.78732	28	10.21268	30
31	9.71829	21	9.93069	8	9.78760	29	10.21240	29
32	9.71850	20	9.93061	8	9.78789	28	10.21211	28
33	9.71870	21	9.93053	7	9.78817	28	10.21183	27
34	9.71891	20	9.93046	8	9.78845	29	10 21155	26
35	9.71911	21	9.93038	8	9.78874	28	10.21126	25
36	9.71932	20	9.93030	8	9.78902	28	10.21098	24
37	9.71952	21	9.93022	8	9.78930	29	10.21070	23
38	9.71973	21	9.93014	7	9.78959	28	10.21041	22
39	9.71994	20	9.93007	8	9.78987	28	10.21013	21
40	9.72014	20	9.92999	8	9.79015	28	10.20985	20
41	9.72034	21	9.92991	8	9.79043	29	10.20957	19
42	9.72055	20	9.92983	7	9.79072	28	10.20928	18
43	9.72075	20	9.92976	8	9.79100	28	10.20900	17
44	9.72096	20	9.92968	8	9.79128	28	10 20872	16
45	9.72116	21	9.92960	8	9.79156	29	10 20844	15
46	9.72137	20	9.92952	8	9.79185	28	10.20815	14
47	9.72157	20	9.92944	8	9.79213	28	10.20787	13
48	9.72177	21	9.92936	7	9.79241	28	10.20759	12
49	9.72198	20	9.92929	8	9.79269	28	10.20731	11
50	9.72218	20	9 92921	8	9.79297	29	10.20703	10
51	9.72238	21	9.92913	8	9.79326	28	10.20674	9
52	9.72259	20	9.92905	8	9.79354	28	10.20646	8
53	9.72279	20	9.92897	8	9.79382	28	10.20618	7
54	9.72299	21	9.92889	8	9.79410	28	10.20590	6
55	9.72320	20	9.92881	7	9.79438	28	10.20562	5
56	9.72340	20	9.92874	8	9.79466	29	10.20534	4
57	9.72360	21	9.92866	8	9.79495	28	10.20505	3
58	9.72381	20	9 92858	8	9.79523	28	10.20477	2
59	9 72401	20	9.92850	8	9.79551	28	10.20449	1
60	9.72421		9 92842		9.79579		10.20421	0
	Cos.		Sin		Cot.		Tang.	

58 Degrees.

LOGARITHMIC SINES AND TANGENTS.

32 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.72421	20	9.92842	8	9.79579	28	10.20421	60
1	9.72441	20	9.92834	8	9.79607	28	10.20393	59
2	9.72461	21	9.92826	8	9.79635	28	10.20365	58
3	9.72482	20	9.92818	8	9.79663	28	10.20337	57
4	9.72502	20	9.92810	7	9.79691	28	10.20309	56
5	9.72522	20	9.92803	8	9.79719	28	10.20281	55
6	9.72542	20	9.92795	8	9.79747	29	10.20253	54
7	9.72562	20	9.92787	8	9.79776	28	10.20224	53
8	9.72582	20	9.92779	8	9.79804	28	10.20196	52
9	9.72602	20	9.92771	8	9.79832	28	10.20168	51
10	9.72622	21	9.92763	8	9.79860	28	10.20140	50
11	9.72643	20	9.92755	8	9.79888	28	10.20112	49
12	9.72663	20	9.92747	8	9.79916	28	10.20084	48
13	9.72683	20	9.92739	8	9.79944	28	10.20056	47
14	9.72703	20	9.92731	8	9.79972	28	10.20028	46
15	9.72723	20	9.92723	8	9.80000	28	10.20000	45
16	9.72743	20	9.92715	8	9.80028	28	10.19972	44
17	9.72763	20	9.92707	8	9.80056	28	10.19944	43
18	9.72783	20	9.92699	8	9.80084	28	10.19916	42
19	9.72803	20	9.92691	8	9.80112	28	10.19888	41
20	9.72823	20	9.92683	8	9.80140	28	10.19860	40
21	9.72843	20	9.92675	8	9.80168	27	10.19832	39
22	9.72863	20	9.92667	8	9.80195	28	10.19805	38
23	9.72883	19	9.92659	8	9.80223	28	10.19777	37
24	9.72902	20	9.92651	8	9.80251	28	10.19749	36
25	9.72922	20	9.92643	8	9.80279	28	10.19721	35
26	9.72942	20	9.92635	8	9.80307	28	10.19693	34
27	9.72962	20	9.92627	8	9.80335	28	10.19665	33
28	9.72982	20	9.92619	8	9.80363	28	10.19637	32
29	9.73002	20	9.92611	8	9.80391	28	10.19609	31
30	9.73022	19	9.92603	8	9.80419	28	10.19581	30
31	9.73041	20	9.92595	8	9.80447	27	10.19553	29
32	9.73061	20	9.92587	8	9.80474	28	10.19526	28
33	9.73081	20	9.92579	8	9.80502	28	10.19498	27
34	9.73101	20	9.92571	8	9.80530	28	10.19470	26
35	9.73121	19	9.92563	8	9.80558	28	10.19442	25
36	9.73140	20	9.92555	9	9.80586	28	10.19414	24
37	9.73160	20	9.92546	8	9.80614	28	10.19358	23
38	9.73180	20	9.92548	8	9.80642	27	10.19331	22
39	9.73200	19	9.92530	8	9.80669	28	10.19303	21
40	9.73219	20	9.92522	8	9.80697	28	10.19397	20
41	9.73239	20	9.92514	8	9.80725	28	10.19275	19
42	9.73259	19	9.92506	8	9.80753	27	10.19247	18
43	9.73278	20	9.92498	8	9.80781	28	10.19219	17
44	9.73298	20	9.92490	8	9.80808	28	10.19192	16
45	9.73318	19	9.92482	9	9.80836	28	10.19164	15
46	9.73337	20	9.92473	8	9.80864	28	10.19136	14
47	9.73357	20	9.92465	8	9.80892	27	10.19108	13
48	9.73377	19	9.92457	8	9.80919	28	10.19081	12
49	9.73396	20	9.92449	8	9.80947	28	10.19053	11
50	9.73416	19	9.92441	8	9.80975	28	10.19025	10
51	9.73435	20	9.92433	8	9.81003	27	10.18997	9
52	9.73455	19	9.92425	9	9.81030	28	10.18970	8
53	9.73474	20	9.92416	8	9.81058	28	10.18942	7
54	9.73494	19	9.92408	8	9.81086	27	10.18914	6
55	9.73513	20	9.92400	8	9.81113	28	10.18887	5
56	9.73533	19	9.92392	8	9.81141	28	10.18859	4
57	9.73552	20	9.92384	8	9.81169	27	10.18831	3
58	9.73572	19	9.92376	9	9.81196	28	10.18804	2
59	9.73591	20	9.92367	8	9.81224	28	10.18776	1
60	9.73611		9.92359		9.81252		10.18748	0
	Cos.		Sin.		Cot.		Tang.	

57 Degrees.

33 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.73611	19	9.92359	8	9.81252	27	10.18748	60
1	9.73630	20	9.92351	8	9.81279	28	10.18721	59
2	9.73650	19	9.92343	8	9.81307	28	10.18693	58
3	9.73669	20	9.92335	9	9.81335	27	10.18665	57
4	9.73689	19	9.92326	8	9.81362	28	10.18638	56
5	9.73708	19	9.92318	9	9.81390	28	10.18610	55
6	9.73727	20	9.92310	8	9.81418	27	10.18582	54
7	9.73747	19	9.92302	9	9.81445	28	10.18555	53
8	9.73766	19	9.92293	8	9.81473	27	10.18527	52
9	9.73785	20	9.92285	8	9.81500	28	10.18500	51
10	9.73805	19	9.92277	8	9.81528	28	10.18472	50
11	9.73824	19	9.92269	9	9.81556	27	10.18444	49
12	9.73843	20	9.92260	8	9.81583	28	10.18417	48
13	9.73863	19	9.92252	8	9.81611	27	10.18389	47
14	9.73882	19	9.92244	9	9.81638	28	10.18362	46
15	9.73901	20	9.92235	8	9.81666	27	10.18334	45
16	9.73921	19	9.92227	8	9.81693	28	10.18307	44
17	9.73940	19	9.92219	8	9.81721	27	10.18279	43
18	9.73959	19	9.92211	9	9.81748	28	10.18252	42
19	9.73978	19	9.92202	8	9.81776	27	10.18224	41
20	9.73997	20	9.92194	8	9.81803	28	10.18197	40
21	9.74017	19	9.92186	9	9.81831	27	10.18169	39
22	9.74037	19	9.92178	8	9.81858	28	10.18142	38
23	9.74055	19	9.92169	8	9.81886	27	10.18114	37
24	9.74074	19	9.92161	9	9.81913	28	10.18087	36
25	9.74093	20	9.92152	8	9.81941	27	10.18059	35
26	9.74113	19	9.92144	8	9.81968	28	10.18032	34
27	9.74132	19	9.92136	9	9.81996	27	10.18004	33
28	9.74151	19	9.92127	8	9.82023	28	10.17977	32
29	9.74170	19	9.92119	8	9.82051	27	10.17949	31
30	9.74189	19	9.92111	9	9.82078	28	10.17922	30
31	9.74208	19	9.92102	8	9.82106	27	10.17894	29
32	9.74227	19	9.92094	8	9.82133	28	10.17867	28
33	9.74256	19	9.92086	9	9.82161	27	10.17839	27
34	9.74265	19	9.92077	8	9.82188	27	10.17812	26
35	9.74284	19	9.92069	9	9.82215	28	10.17785	25
36	9.74303	19	9.92060	8	9.82243	27	10.17757	24
37	9.74322	19	9.92052	8	9.82270	28	10.17730	23
38	9.74341	19	9.92044	9	9.82298	27	10.17702	22
39	9.74360	19	9.92035	8	9.82325	27	10.17675	21
40	9.74379	19	9.92027	9	9.82352	28	10.17648	20
41	9.74398	19	9.92018	8	9.82380	27	10.17620	19
42	9.74417	19	9.92010	8	9.82407	28	10.17593	18
43	9.74436	19	9.92002	9	9.82435	27	10.17565	17
44	9.74455	19	9.92993	8	9.82462	27	10.17538	16
45	9.74474	19	9.91985	9	9.82489	28	10.17511	15
46	9.74493	19	9.91976	8	9.82517	27	10.17483	14
47	9.74512	19	9.91968	9	9.82544	27	10.17456	13
48	9.74531	18	9.91959	8	9.82571	28	10.17429	12
49	9.74549	19	9.91951	9	9.82599	27	10.17401	11
50	9.74568	19	9.91942	8	9.82626	27	10.17374	10
51	9.74587	19	9.91934	9	9.82653	28	10.17347	9
52	9.74606	19	9.91925	8	9.82681	27	10.17319	8
53	9.74625	19	9.91917	9	9.82708	27	10.17292	7
54	9.74644	18	9.91908	8	9.82735	27	10.17265	6
55	9.74662	19	9.91900	9	9.82762	28	10.17238	5
56	9.74681	19	9.91891	8	9.82790	27	10.17210	4
57	9.74700	19	9.91883	9	9.82817	27	10.17183	3
58	9.74719	18	9.91874	8	9.82844	27	10.17156	2
59	9.74737	19	9.91866	9	9.82871	28	10.17129	1
60	9.74756		9.91857		9.82899		10.17101	0
	Cos.		Sin.		Cot.		Tang.	

56 Degrees.

LOGARITHMIC SINES AND TANGENTS.

34 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.74756	19	9.91857	8	9.82899	27	10.17101	60
1	9.74775	19	9.91849	9	9.82926	27	10.17074	59
2	9.74794	18	9.91840	8	9.82953	27	10.17047	58
3	9.74812	19	9.91832	9	9.82980	28	10.17020	57
4	9.74831	19	9.91823	8	9.83008	27	10.16992	56
5	9.74850	18	9.91815	9	9.83035	27	10.16965	55
6	9.74868	19	9.91806	8	9.83062	27	10.16938	54
7	9.74887	19	9.91798	9	9.83089	28	10.16911	53
8	9.74906	18	9.91789	8	9.83117	27	10.16883	52
9	9.74924	19	9.91781	9	9.83144	27	10.16856	51
10	9.74943	18	9.91772	9	9.83171	27	10.16829	50
11	9.74961	19	9.91763	8	9.83198	27	10.16802	49
12	9.74980	19	9.91755	9	9.83225	27	10.16775	48
13	9.74999	18	9.91746	8	9.83252	28	10.16748	47
14	9.75016	19	9.91738	9	9.83280	27	10.16720	46
15	9.75036	18	9.91729	9	9.83307	27	10.16693	45
16	9.75054	19	9.91720	8	9.83334	27	10.16666	44
17	9.75073	18	9.91712	9	9.83361	27	10.16639	43
18	9.75091	19	9.91703	8	9.83388	27	10.16612	42
19	9.75110	18	9.91695	9	9.83415	27	10.16585	41
20	9.75128	19	9.91686	9	9.83442	28	10.16558	40
21	9.75147	18	9.91677	8	9.83470	27	10.16530	39
22	9.75165	19	9.91669	9	9.83497	27	10.16503	38
23	9.75184	18	9.91660	9	9.83524	27	10.16476	37
24	9.75202	19	9.91651	8	9.83551	27	10.16449	36
25	9.75221	18	9.91643	9	9.83578	27	10.16422	35
26	9.75239	19	9.91634	9	9.83605	27	10.16395	34
27	9.75258	18	9.91625	8	9.83632	27	10.16368	33
28	9.75276	18	9.91617	9	9.83659	27	10.16341	32
29	9.75294	19	9.91608	9	9.83686	27	10.16314	31
30	9.75313	18	9.91599	8	9.83713	27	10.16287	30
31	9.75331	19	9.91591	9	9.83740	28	10.16260	29
32	9.75350	18	9.91582	9	9.83768	27	10.16232	28
33	9.75368	18	9.91573	8	9.83795	27	10.16205	27
34	9.75386	19	9.91565	9	9.83822	27	10.16178	26
35	9.75405	18	9.91556	9	9.83849	27	10.16151	25
36	9.75423	18	9.91547	9	9.83876	27	10.16124	24
37	9.75441	18	9.91538	8	9.83903	27	10.16097	23
38	9.75459	19	9.91530	9	9.83930	27	10.16070	22
39	9.75478	18	9.91521	9	9.83957	27	10.16043	21
40	9.75496	18	9.91512	8	9.83984	27	10.16016	20
41	9.75514	19	9.91504	9	9.84011	27	10.15989	19
42	9.75533	18	9.91495	9	9.84038	27	10.15962	18
43	9.75551	18	9.91486	9	9.84065	27	10.15935	17
44	9.75569	18	9.91477	8	9.84092	27	10.15908	16
45	9.75587	18	9.91469	9	9.84119	27	10.15881	15
46	9.75605	19	9.91460	9	9.84146	27	10.15854	14
47	9.75624	18	9.91451	9	9.84173	27	10.15827	13
48	9.75642	18	9.91442	9	9.84200	27	10.15800	12
49	9.75660	18	9.91433	8	9.84227	27	10.15773	11
50	9.75678	18	9.91425	9	9.84254	26	10.15746	10
51	9.75696	18	9.91416	9	9.84280	27	10.15720	9
52	9.75714	19	9.91407	9	9.84307	27	10.15693	8
53	9.75733	18	9.91398	9	9.84334	27	10.15666	7
54	9.75751	18	9.91389	8	9.84361	27	10.15639	6
55	9.75769	18	9.91381	9	9.84388	27	10.15612	5
56	9.75787	18	9.91372	9	9.84415	27	10.15585	4
57	9.75805	18	9.91363	9	9.84442	27	10.15558	3
58	9.75823	18	9.91354	9	9.84469	27	10.15531	2
59	9.75841	18	9.91345	9	9.84496	27	10.15504	1
60	9.75859		9.91336		9.84523		10.15477	0
	Cos.		Sin.		Cot.		Tang.	

55 Degrees.

35 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.75859	18	9.91336	8	9.84523	27	10.15477	60
1	9.75877	18	9.91328	9	9.84550	26	10.15450	59
2	9.75895	18	9.91319	9	9.84576	27	10.15424	58
3	9.75913	18	9.91310	9	9.84603	27	10.15397	57
4	9.75931	18	9.91301	9	9.84630	27	10.15370	56
5	9.75949	18	9.91292	9	9.84657	27	10.15343	55
6	9.75967	18	9.91283	9	9.84684	27	10.15316	54
7	9.75985	18	9.91274	8	9.84711	27	10.15289	53
8	9.76003	18	9.91266	9	9.84738	26	10.15262	52
9	9.76021	18	9.91257	9	9.84764	27	10.15236	51
10	9.76039	18	9.91248	9	9.84791	27	10.15209	50
11	9.76057	18	9.91239	9	9.84818	27	10.15183	49
12	9.76075	18	9.91230	9	9.84845	27	10.15155	48
13	9.76093	18	9.91221	9	9.84872	27	10.15128	47
14	9.76111	18	9.91212	9	9.84899	26	10.15101	46
15	9.76129	17	9.91203	9	9.84925	27	10.15075	45
16	9.76146	18	9.91194	9	9.84952	27	10.15048	44
17	9.76164	18	9.91185	9	9.84979	27	10.15021	43
18	9.76182	18	9.91176	9	9.85006	27	10.14994	42
19	9.76200	18	9.91167	9	9.85033	26	10.14967	41
20	9.76218	18	9.91158	9	9.85059	27	10.14941	40
21	9.76236	17	9.91149	8	9.85086	27	10.14914	39
22	9.76253	18	9.91141	9	9.85113	27	10.14887	38
23	9.76271	18	9.91132	9	9.85140	26	10.14860	37
24	9.76289	18	9.91123	9	9.85166	27	10.14834	36
25	9.76307	17	9.91114	9	9.85193	27	10.14807	35
26	9.76324	18	9.91105	9	9.85220	27	10.14780	34
27	9.76342	18	9.91096	9	9.85247	26	10.14753	33
28	9.76360	18	9.91087	9	9.85273	27	10.14727	32
29	9.76378	17	9.91078	9	9.85300	27	10.14700	31
30	9.76395	18	9.91069	9	9.85327	27	10.14673	30
31	9.76413	18	9.91060	9	9.85354	26	10.14646	29
32	9.76431	17	9.91051	9	9.85380	27	10.14620	28
33	9.76448	18	9.91042	9	9.85407	27	10.14593	27
34	9.76466	18	9.91033	10	9.85434	26	10.14566	25
35	9.76484	17	9.91023	9	9.85460	27	10.14540	25
36	9.76501	18	9.91014	9	9.85487	27	10.14513	24
37	9.76519	18	9.91005	9	9.85514	26	10.14486	23
38	9.76537	17	9.90996	9	9.85540	27	10.14460	22
39	9.76554	18	9.90987	9	9.85567	27	10.14435	21
40	9.76572	18	9.90978	9	9.85594	26	10.14406	20
41	9.76590	17	9.90969	9	9.85620	27	10.14380	19
42	9.76607	18	9.90960	9	9.85647	27	10.14353	18
43	9.76625	17	9.90951	9	9.85674	26	10.14326	17
44	9.76642	18	9.90942	9	9.85700	27	10.14300	16
45	9.76660	17	9.90933	9	9.85727	27	10.14273	15
46	9.76677	18	9.90924	9	9.85754	26	10.14246	14
47	9.76695	17	9.90915	9	9.85780	27	10.14220	13
48	9.76712	18	9.90906	10	9.85807	27	10.14193	12
49	9.76730	17	9.90896	9	8.85834	26	10.14166	11
50	9.76747	18	9.90887	9	9.85860	27	10.14140	10
51	9.76765	17	9.90878	9	9.85887	26	10.14113	9
52	9.46782	18	9.90869	9	9.85913	27	10.14087	8
53	9.76800	17	9.90860	9	9.85940	27	10.14060	7
54	9.76817	18	9.90851	9	9.85967	26	10.14033	6
55	9.76835	17	9.90842	10	9.85993	27	10.14007	5
56	9.76852	18	9.90832	9	9.86020	26	10.13980	4
57	9.76870	17	9.90823	9	9.86046	27	10.13954	3
58	9.76887	17	9.90814	9	9.86073	27	10.13927	2
59	9.76904	18	9.90805	9	9.86100	26	10.13900	1
60	9.76922		9.90796		9.86126		10.13874	0
	Cos.		Sin		Cot		Tang.	

54 Degrees.

LOGARITHMIC SINES AND TANGENTS.

36 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.76922	17	9.90796	9	9.86126	27	10.13874	60
1	9.76939	18	9.90787	10	9.86153	26	10.13847	59
2	9.76957	17	9.90777	9	9.86179	27	10.13821	58
3	9.76974	17	9.90768	9	9.86206	26	10.13794	57
4	9.76991	18	9.90759	9	9.86232	27	10.13768	56
5	9.77009	17	9.90750	9	9.86259	26	10.13741	55
6	9.77026	17	9.90741	10	9.86285	27	10.13715	51
7	9.77043	18	9.90731	9	9.86312	26	10.13688	53
8	9.77061	17	9.90722	9	9.86338	27	10.13662	52
9	9.77078	17	9.90713	9	9.86365	27	10.13635	51
10	9.77095	17	9.90704	10	9.86392	26	10.13608	50
11	9.77112	18	9.90694	9	9.86418	27	10.13582	49
12	9.77130	17	9.90685	9	9.86445	26	10.13555	48
13	9.77147	17	9.90676	9	9.86471	27	10.13529	47
14	9.77164	17	9.90667	10	9.86498	26	10.13502	46
15	9.77181	18	9.90657	9	9.86524	27	10.13476	45
16	9.77199	17	9.90648	9	9.86551	26	10.13449	44
17	9.77216	17	9.90639	9	9.86577	26	10.13423	43
18	9.77233	17	9.90630	10	9.86603	27	10.13397	42
19	9.77250	18	9.90620	9	9.86630	26	10.13370	41
20	9.77268	17	9.90611	9	9.86656	27	10.13344	40
21	9.77285	17	9.90602	10	9.86683	26	10.13317	39
22	9.77302	17	9.90592	9	9.86709	27	10.13291	38
23	9.77319	17	9.90583	9	9.86736	26	10.13264	37
24	9.77336	17	9.90574	9	9.86762	27	10.13238	36
25	9.77353	17	9.90565	10	9.86789	26	10.13211	35
26	9.77370	17	9.90555	9	9.86815	27	10.13185	34
27	9.77387	18	9.90546	9	9.86842	26	10.13158	33
28	9.77405	17	9.90537	10	9.86868	26	10.13132	32
29	9.77422	17	9.90527	9	9.86894	27	10.13106	31
30	9.77439	17	9.90518	9	9.86921	26	10.13079	30
31	9.77456	17	9.90509	10	9.86947	27	10.13053	29
32	9.77473	17	9.90499	9	9.86974	26	10.13026	28
33	9.77490	17	9.90490	10	9.87000	27	10.13000	27
34	9.77507	17	9.90480	9	9.87027	26	10.12073	26
35	9.77524	17	9.90471	9	9.87053	26	10.12947	25
36	9.77541	17	9.90462	10	9.87079	27	10.12921	24
37	9.77558	17	9.90452	9	9.87106	25	10.12894	23
38	9.77575	17	9.90443	9	9.87132	26	10.12868	22
39	9.77592	17	9.90434	10	9.87158	27	10.12842	21
40	9.77609	17	9.90424	9	9.87185	26	10.12815	20
41	9.77626	17	9.90415	10	9.87211	27	10.12789	19
42	9.77643	17	9.90405	9	9.87238	26	10.12762	18
43	9.77660	17	9.90396	10	9.87264	26	10.12736	17
44	9.77677	17	9.90386	9	9.87290	27	10.12710	16
45	9.77694	17	9.90377	9	9.87317	26	10.12683	15
46	9.77711	17	9.90368	10	9.87343	26	10.12657	14
47	9.77728	16	9.90358	9	9.87369	27	10.12631	13
48	9.77744	17	9.90349	10	9.87396	26	10.12604	12
49	9.77761	17	9.90339	9	9.87422	26	10.12578	11
50	9.77778	17	9.90330	10	9.87448	27	10.12552	10
51	9.77795	17	9.90320	9	9.87475	26	10.12525	9
52	9.77812	17	9.90311	10	9.87501	26	10.12499	8
53	9.77829	17	9.90301	9	9.87527	27	10.12473	7
54	9.77846	16	9.90292	10	9.87554	26	10.12446	6
55	9.77862	17	9.90282	9	9.87580	26	10.12420	5
56	9.77879	17	9.90273	10	9.87606	27	10.12394	4
57	9.77896	17	9.90263	9	9.87633	26	10.12367	3
58	9.77913	17	9.90254	10	9.87659	26	10.12341	2
59	9.77930	16	9.90244	9	9.87685	26	10.12315	1
60	9.77946		9.90235		8.87711		10.12289	0
	Cos.		Sin.		Cot.		Tang.	

53 Degrees.

37 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.77946	17	9.90235	10	9.87711	27	10.12289	60
1	9.77963	17	9.90223	9	9.87738	26	10.12262	59
2	9.77980	17	9.90216	10	9.87764	26	10.12236	58
3	9.77997	16	9.90206	9	9.87790	27	10.12210	57
4	9.78013	17	9.90197	10	9.87817	26	10.12183	56
5	9.78030	17	9.90187	9	9.87843	26	10.12157	55
6	9.78047	16	9.90178	10	9.87869	26	10.12131	54
7	9.78063	17	9.90168	9	9.87895	27	10.12105	3
8	9.78080	17	9.90159	10	9.87922	26	10.12078	52
9	9.78097	16	9.90149	10	9.87948	26	10.12052	51
10	9.78113	17	9.90139	9	9.87974	26	10.12026	50
11	9.78130	17	9.90130	10	9.88000	27	10.12000	49
12	9.78147	16	9.90120	9	9.88027	26	10.11973	48
13	9.78163	17	9.90111	10	9.88053	26	10.11947	47
14	9.78180	17	9.90101	10	9.88079	26	10.11921	46
15	9.78197	16	9.90091	9	9.88105	26	10.11895	45
16	9.78213	17	9.90082	10	9.88131	27	10.11869	44
17	9.78230	16	9.90072	9	9.88158	26	10.11842	43
18	9.78246	17	9.90063	10	9.88184	26	10.11816	42
19	9.78263	17	9.90053	10	9.88210	26	10.11790	41
20	9.78280	16	9.90043	9	9.88236	26	10.11764	40
21	9.78296	17	9.90034	10	9.88262	27	10.11738	39
22	9.78313	16	9.90024	10	9.88289	26	10.11711	38
23	9.78329	17	9.90014	9	9.88315	26	10.11685	37
24	9.78346	16	9.90005	10	9.88341	26	10.11659	36
25	9.78362	17	9.89995	10	9.88367	26	10.11633	35
26	9.78379	16	9.89985	9	9.88393	27	10.11607	34
27	9.78395	17	9.89976	10	9.88420	26	10.11580	33
28	9.78412	16	9.89966	10	9.88446	26	10.11554	32
29	9.78428	17	9.89956	9	9.88472	26	10.11528	31
30	9.78445	16	9.89947	10	9.88498	26	10.11502	30
31	9.78461	17	9.89937	10	9.88524	26	10.11476	29
32	9.78478	16	9.99927	9	9.88550	27	10.11450	28
33	9.78494	16	9.89918	10	9.88577	26	10.11423	27
34	9.78510	17	9.89908	10	9.88603	26	10.11397	26
35	9.78527	16	9.89898	10	9.88629	26	10.11371	25
36	9.78543	17	9.89888	9	9.88655	26	10.11345	24
37	9.78560	16	9.89879	10	9.88681	26	10.11319	23
38	9.78576	16	9.89869	10	9.88707	26	10.11293	22
39	9.78592	17	9.89859	10	9.88733	26	10.11267	21
40	9.78609	16	9.89849	9	9.88759	27	10.11241	20
41	9.78625	17	9.89840	10	9.88786	26	10.11214	19
42	9.78642	16	9.89830	10	9.88812	26	10.11188	18
43	9.78658	16	9.89820	10	9.88838	26	10.11162	17
44	9.78674	17	9.89810	9	9.88864	26	10.11136	16
45	9.78691	16	9.89801	10	9.88890	26	10.11110	15
46	9.78707	16	9.89791	10	9.88916	26	10.11084	14
47	9.78723	16	9.89781	10	9.88942	26	10.11058	13
48	9.78739	17	9.89771	10	9.88968	26	10.11032	12
49	9.78756	16	9.89761	9	9.88994	26	10.1100	11
50	9.78772	16	9.89752	10	9.89020	26	10.10980	10
51	9.78788	17	9.89742	10	9.89046	27	10.10954	9
52	9.78805	16	9.89732	10	9.89073	26	10.10927	8
53	9.78821	16	9.89722	10	9.89099	26	10.10901	7
54	9.78837	16	9.89712	10	9.89125	26	10.10875	6
55	9.78853	16	9.89702	9	9.89151	26	10.10849	5
56	9.78869	17	9.89693	10	9.89177	26	10.10823	4
57	9.78886	16	9.89683	10	9.89203	26	10.10797	3
58	9.78902	16	9.89673	10	9.89229	26	10.10771	2
59	9.78918	16	9.89663	10	9.89255	26	10.10745	1
60	9.78934		9.89653		9.89281		10.10719	
	Cos.		Sin.		Cot.		Tang.	

52 Degrees.

LOGARITHMIC SINES AND TANGENTS.

38 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.78934	16	9.89653	10	9.89281	26	10.10719	60
1	9.78950	17	9.89643	10	9.89307	26	10.10693	59
2	9.78967	16	9.89633	9	9.89333	26	10.10667	58
3	9.78983	19	9.89624	10	9.89359	26	10.10641	57
4	9.78999	16	9.89614	10	9.89385	26	10.10615	56
5	9.79015	16	9.89604	10	9.89411	26	10.10589	55
6	9.79031	16	9.89594	10	9.89437	26	10.10563	54
7	9.79047	16	9.89584	10	9.89463	26	10.10537	53
8	9.79063	16	9.89574	10	9.89489	26	10.10511	52
9	9.79079	16	9.89564	10	9.89515	26	10.10485	51
10	9.79095	16	9.89554	10	9.89541	26	10.10459	50
11	9.79111	17	9.89544	10	9.89567	26	10.10433	49
12	9.79128	16	9.89534	10	9.89593	26	10.10407	48
13	9.79144	16	9.89524	10	9.89619	26	10.10381	47
14	9.79160	16	9.89514	10	9.89645	26	10.10355	46
15	9.79176	16	9.89504	9	9.89671	26	10.10329	45
16	9.79192	16	9.89495	10	9.89697	26	10.10303	44
17	9.79208	16	9.89485	10	9.89723	26	10.10277	43
18	9.79224	16	9.89475	10	9.89749	26	10.10251	42
19	9.79240	16	9.89465	10	9.89775	26	10.10225	41
20	9.79256	16	9.89455	10	9.89801	26	10.10199	40
21	9.79272	16	9.89445	10	9.89827	26	10.10173	39
22	9.79288	16	9.89435	10	9.89853	26	10.10147	38
23	9.79304	15	9.89425	10	9.89879	26	10.10121	37
24	9.79319	16	9.89415	10	9.89905	26	10.10095	36
25	9.79335	16	9.89405	10	9.89931	26	10.10069	35
26	9.79351	16	9.89395	10	9.89957	26	10.10043	34
27	9.79367	16	9.89385	10	9.89983	26	10.10017	33
28	9.79383	16	9.89375	11	9.90009	26	10.09991	32
29	9.79399	16	9.89364	10	9.90035	26	10.09965	31
30	9.79415	16	9.89354	10	9.90061	25	10.09939	30
31	9.79421	16	9.89344	10	9.90086	26	10.09914	29
32	9.79447	16	9.89334	10	9.90112	26	10.09888	28
33	9.79463	15	9.89324	10	9.90138	26	10.09862	27
34	9.79478	16	9.89314	10	9.90164	26	10.09836	26
35	9.79494	16	9.89304	10	9.90190	26	10.09810	25
36	9.79510	16	9.89294	10	9.90216	26	10.09784	24
37	9.79526	16	9.89284	10	9.90242	26	10.09758	23
38	9.79542	16	9.89274	10	9.90268	26	10.09732	22
39	9.79558	15	9.89264	10	9.90294	26	10.09706	21
40	9.79573	16	9.89254	10	9.90320	26	10.09680	20
41	9.79589	16	9.89244	11	9.90346	25	10.09654	19
42	9.79605	16	9.89233	10	9.90371	26	10.09629	18
43	9.79621	15	9.89223	10	9.90397	26	10.09603	17
44	9.79636	16	9.89213	10	9.90428	26	10.09577	16
45	9.78652	16	9.89203	10	9.90449	26	10.09551	15
46	9.79668	16	9.89193	10	9.90475	26	10.09525	14
47	9.79684	15	9.89184	10	9.90501	26	10.09499	13
48	9.79699	16	9.89173	11	9.90527	26	10.09473	12
49	8.79715	16	9.89162	10	9.90553	25	10.09447	11
50	9.79731	15	9.89152	10	9.90578	26	10.09422	10
51	9.79746	16	9.89142	10	9.90604	26	10.09396	9
52	9.79762	16	9.89132	10	9.90630	26	10.09370	8
53	9.79778	15	9.89122	10	9.90656	26	10.09344	7
54	9.79793	16	9.89112	11	9.90682	26	10.09318	6
55	9.79809	16	9.89101	10	9.90708	26	10.09292	5
56	9.79825	15	9.89091	10	9.90734	25	10.09266	4
57	9.79840	16	9.89081	10	9.90759	26	10.09241	3
58	9.79856	6	9.89071	11	9.90786	26	10.09215	2
59	9.79872	15	9.89060	10	9.90811	26	10.09189	1
60	9.79887		9.89050		9.90837		10.09163	0
	Cos.		Sin.		Cot.		Tang.	

51 Degrees.

39 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.79887	16	9.89050	10	9.90837	26	10.09163	60
1	9.79903	15	9.89040	10	9.90863	26	10.09137	59
2	9.79918	16	9.89030	10	9.90889	25	10.09111	58
3	9.79934	16	9.89020	11	9.90914	26	10.09086	57
4	9.79954	15	9.89009	10	9.90940	26	10.09060	56
5	9.79965	16	9.88999	10	9.90966	26	10.09034	55
6	9.79981	15	9.88989	11	9.90992	26	10.09008	54
7	9.79996	16	9.88978	10	9.91018	25	10.08982	53
8	9.80012	15	9.88968	10	9.91043	26	10.08957	52
9	9.80027	16	9.88958	10	9.91069	26	10.08931	51
10	9.80043	15	9.88948	11	9.91095	26	10.08905	50
11	9.80058	16	9.88937	10	9.91121	26	10.08879	49
12	9.80074	15	9.88927	10	9.91147	25	10.08853	48
13	9.80089	16	9.88917	11	9.91172	25	10.08828	47
14	9.80105	15	9.88906	10	9.91198	26	10.08802	46
15	9.80120	16	9.88896	10	9.91224	26	10.08776	45
16	9.80136	15	9.88886	11	9.91250	26	10.08750	44
17	9.80151	15	9.88875	10	9.91276	25	10.08724	43
18	9.80166	16	9.88865	10	9.91301	26	10.08699	42
19	9.80182	15	9.88855	11	9.91327	26	10.08673	41
20	9.80197	16	9.88844	10	9.91353	26	10.08647	40
21	9.80213	15	9.88834	10	9.91379	25	10.08621	39
22	9.80228	16	9.88824	11	9.91404	26	10.08596	38
23	9.80244	15	9.88813	10	9.91430	26	10.08570	37
24	9.80259	15	9.88803	10	9.91456	26	10.08544	36
25	9.80274	16	9.88793	11	9.91482	25	10.08518	35
26	9.80290	15	9.88782	10	9.91507	26	10.08493	34
27	9.80305	15	9.88772	11	9.91533	26	10.08467	33
28	9.80320	16	9.88761	10	9.91559	26	10.08441	32
29	9.80336	15	9.88751	10	9.91585	25	10.08415	31
30	9.80351	15	9.88741	11	9.91610	26	10.08390	30
31	9.80366	16	9.88730	10	9.91636	26	10.08364	29
32	9.80382	15	9.88720	11	9.91662	26	10.08338	28
33	9.80497	15	9.88709	10	9.91688	25	10.08312	27
34	9.80412	16	9.88699	11	9.91713	26	10.08287	26
35	9.80428	15	9.88688	10	9.91739	26	10.08261	25
36	9.80443	15	9.88678	10	9.91765	26	10.08235	24
37	9.80458	15	9.88668	11	9.91791	25	10.08209	23
38	9.80473	16	9.88657	10	9.91816	26	10.08184	22
39	9.80489	15	9.88647	11	9.91842	26	10.08151	21
40	9.80504	15	9.88636	10	9.91868	25	10.08132	20
41	9.80519	15	9.88626	11	9.91893	26	10.08107	19
42	9.80534	16	9.88615	10	9.91919	26	10.08081	18
43	9.80550	15	9.88605	11	9.91945	26	10.08055	17
44	9.80565	15	9.88594	10	9.91971	25	10.08029	16
45	9.80580	15	9.88584	11	9.91996	26	10.08004	15
46	9.80595	15	9.88573	10	9.92022	26	10.07978	14
47	9.80610	15	9.88563	11	9.92048	25	10.07952	13
48	9.80625	16	9.88552	10	9.92073	26	10.07927	12
49	9.80641	15	9.88542	11	9.92099	26	10.07901	11
50	9.80656	15	9.88531	10	9.92125	25	10.07875	10
51	9.80671	15	9.88521	11	9.92150	26	10.07850	9
52	9.80686	15	9.88510	11	9.92176	26	10.07824	8
53	9.80701	15	9.88499	10	9.92202	25	10.07798	7
54	9.80716	15	9.88489	11	9.92227	26	10.07773	6
55	9.80731	15	9.88478	10	9.92253	26	10.07747	5
56	9.80746	16	9.88468	11	9.92279	25	10.07721	4
57	9.80762	15	9.88457	10	9.92304	26	10.07696	3
58	9.80777	15	9.88447	11	9.92330	26	10.07670	2
59	9.80792	15	9.88436	11	9.92356	25	10.07644	1
60	9.80807		9.88425		9.92381		10.07619	0
	Cos.		Sin.		Cot.		Tang.	

50 Degrees.

LOGARITHMIC SINES AND TANGENTS.

40 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.80807	15	9.88425	10	9.92381	26	10.07619	60
1	9.80822	15	9.88415	11	9.92407	26	10.07593	59
2	9.80837	15	9.88404	10	9.92433	25	10.07567	58
3	9.80852	15	9.88394	11	9.92458	26	10.07542	57
4	9.80867	15	9.88383	11	9.92484	26	10.07516	56
5	9.80832	15	9.88371	10	9.92510	25	10.07490	55
6	9.80897	15	9.88362	11	9.92535	26	10.07465	54
7	9.80912	15	9.88351	11	9.92561	26	10.07439	53
8	9.80927	15	9.88340	10	9.92587	25	10.07413	52
9	9.80942	15	9.88330	11	9.92612	26	10.07388	51
10	9.80957	15	9.88319	11	9.92638	25	10.07362	50
11	9.80972	15	9.88308	10	9.92663	26	10.07337	49
12	9.80987	15	9.88298	11	9.92689	26	10.07311	48
13	9.81002	15	9.88287	11	9.92715	25	10.07285	47
14	9.81017	15	9.88276	10	9.92740	26	10.07260	46
15	9.81032	15	9.88266	11	9.92766	26	10.07234	45
16	9.81047	14	9.88255	11	9.92792	25	10.07208	44
17	9.81061	15	9.88244	10	9.92817	26	10.07183	43
18	9.81076	15	9.88234	11	9.92843	25	10.07157	42
19	9.81091	15	9.88223	11	9.92868	26	10.07132	41
20	9.81106	15	9.88212	11	9.92894	26	10.07106	40
21	9.81121	15	9.88201	10	9.92920	25	10.07080	39
22	9.81136	15	9.88191	11	9.92945	26	10.07055	38
23	9.81151	15	9.88180	11	9.92971	25	10.07029	37
24	9.81166	14	9.88169	11	9.92996	26	10.07004	36
25	9.81180	15	9.88158	10	9.93022	26	10.06978	35
26	9.81195	15	9.88148	11	9.93048	25	10.06952	34
27	9.81210	15	9.88137	11	9.93073	26	10.06927	33
28	9.81225	15	9.88126	11	9.93099	25	10.06901	32
29	9.81240	14	9.88115	10	9.93124	26	10.06876	31
30	9.81254	15	9.88105	11	9.93150	25	10.06850	30
31	9.81269	15	9.88094	11	9.93175	26	10.06825	29
32	9.81284	15	9.88083	11	9.93201	26	10.06799	28
33	9.81299	15	9.88072	11	9.93227	25	10.06773	27
34	9.81314	14	9.88061	10	9.93252	26	10.06748	26
35	9.81328	15	9.88051	11	9.93278	25	10.06722	25
36	9.81343	15	9.88040	11	9.93303	26	10.06697	24
37	9.81358	14	9.88029	11	9.93329	25	10.06671	23
38	9.81272	15	9.88018	11	9.93354	26	10.06646	22
39	9.81387	15	9.88007	11	9.93380	26	10.06620	21
40	9.81402	15	9.87996	11	9.93406	25	10.06594	20
41	9.81417	14	9.87985	10	9.93431	26	10.06569	19
42	9.81431	15	9.87975	11	9.93457	25	10.06543	18
43	9.81446	15	9.87964	11	9.93482	26	10.06518	17
44	9.81461	14	9.87953	11	9.93508	25	10.06492	16
45	9.81475	15	9.87942	11	9.93533	26	10.06467	15
46	9.81490	15	9.87931	11	9.93559	25	10.06441	14
47	9.81505	14	9.87920	11	9.93584	26	10.06416	13
48	9.81519	15	9.87909	11	9.93610	26	10.06390	12
49	9.81534	15	9.87898	11	9.93636	25	10.06364	11
50	9.81549	14	9.87887	10	9.93661	26	10.06339	10
51	9.81563	15	9.87877	11	9.93687	25	10.06313	9
52	9.81578	14	9.87866	11	9.93712	26	10.06288	8
53	9.81592	15	9.87855	11	9.93738	25	10.06262	7
54	9.81607	15	9.87844	11	9.93763	26	10.06237	6
55	9.81622	14	9.87833	11	9.93789	25	10.06211	5
56	9.81636	15	9.87822	11	9.93814	26	10.06186	4
57	9.81651	14	9.87811	11	9.93840	25	10.06160	3
58	9.81665	15	9.878[illegible]	11	9.93865	26	10.06135	2
59	9.81680	14	9.87789	11	9.93891	25	10.06109	1
60	9.81694		9.87778		9.93916		10.06084	0
	Cos.		Sin.		Cot.		Tang.	

49 Degrees.

41 Degrees.

′	Sin.	D.	Cos.	D.	Tang	D	Cot.	′
0	9.81694	15	9.87778	11	9.93916	26	10.06084	60
1	9.81709	14	9.87767	11	9.93942	25	10.06058	59
2	9.81723	15	9.87756	11	9.93967	26	10.06033	58
3	9.81738	14	9.87745	11	9.93993	25	10.06007	57
4	9.81752	15	9.87734	11	9.94018	26	10.05982	56
5	9.81767	14	9.87723	11	9.94044	25	10.05956	55
6	9.81781	15	9.87712	11	9.94069	26	10.05931	54
7	9.81796	14	9.87701	11	9.94095	25	10.05905	53
8	9.81810	15	9.07690	11	9.94120	26	10.05880	52
9	9.81825	14	9.87679	11	9.94146	25	10.05854	51
10	9.81839	15	9.87668	11	9.94171	26	10.05829	50
11	9.81854	14	9.87657	11	9.94197	25	10.05803	49
12	9.81868	14	9.87646	11	9.94222	26	10.05778	48
13	9.81882	15	9.87635	11	9.94248	25	10.05752	47
14	9.81897	14	9.87624	11	9.94273	26	10.05727	46
15	9.81911	15	9.87613	12	9.94299	25	10.05701	45
16	9.81926	14	9.87601	11	9.94324	26	10.05676	44
17	9.81940	15	9.87590	11	9.94350	25	10.05650	43
18	9.81955	14	9.87579	11	9.94375	26	10.05625	42
19	9.81969	14	9.87568	11	9.94401	25	10.05599	41
20	9.81983	15	9.87557	11	9.94426	26	10.05574	40
21	9.81998	14	9.87546	11	9.94452	25	10.05548	39
22	9.82012	14	9.87535	11	9.94477	26	10.05528	38
23	9.82026	15	9.87524	11	9.94503	25	10.05497	37
24	9.82041	14	9.87513	12	9.94528	26	10.05472	36
25	9.82055	14	9.87501	11	9.94554	25	10.05446	35
26	9.82069	15	9.87490	11	9.94579	25	10.05421	34
27	9.82084	14	9.87479	11	9.94604	26	10.05396	33
28	9.82098	14	9.87468	11	9.94630	25	10.05470	32
29	9.82112	14	9.87457	11	9.94655	26	10.05345	31
30	9.82126	15	9.87446	12	9.94681	25	10.05319	30
31	9.82141	14	9.87434	11	9.94706	26	10.05294	29
32	9.82155	14	9.87423	11	9.94732	25	10.05268	28
33	9.82169	15	9.87412	11	9.94757	26	10.05243	27
34	9.82184	14	9.97401	11	9.94783	25	10.05217	26
35	9.82198	14	9.87390	12	9.94808	26	10.05192	25
36	9.82212	14	9.87378	11	9.94834	25	10.05166	24
37	9.82226	14	9.87367	11	9.94859	25	10.05141	23
38	9.82240	15	9.87356	11	9.94884	26	10.05116	22
39	9.82255	14	9.87345	11	9.94910	25	10.05090	21
40	9.82269	14	9.87334	12	9.94936	26	10.05065	20
41	9.82283	14	9.87322	11	9.94961	25	10.05039	19
42	9.82297	14	9.87311	11	9.94986	26	10.05014	18
43	9.82311	15	9.87300	12	9.95012	25	10.04988	17
44	9.82326	14	9.87288	11	9.95037	25	10.04963	16
45	9.82340	14	9.87277	11	9.95062	26	10.04938	15
46	9.82354	14	9.87266	11	9.95088	25	10.04912	14
47	9.82368	14	9.87255	12	9.95113	26	10.04887	13
48	9.92382	14	9.87243	11	9.95139	25	10.04861	12
49	9.82396	14	9.87232	11	9.95164	26	10.04836	11
50	9.82410	14	9.87221	12	9.95190	25	10.04810	10
51	9.82424	15	9.87209	11	9.95215	25	10.04785	9
52	9.82439	14	9.87298	11	9.95240	26	10.04760	8
53	9.82453	14	9.87187	12	9.95266	25	10.04734	7
54	9.82467	14	9.87175	11	9.95291	26	10.04709	6
55	9.82481	14	9.87164	11	9.95317	25	10.04683	5
56	9.82495	14	9.87153	12	9.95342	26	10.04658	4
57	9.82509	14	9.87141	11	9.95368	25	0.04632	3
58	9.82523	14	9.87130	11	9.95393	25	10.04607	2
59	9.82537	14	9.87119	12	9.95418	26	10.04582	1
60	9.82551		9.87107		9.95444		10.04556	0
	Cos.		Sin.		Cot.		Tang.	

48 Degrees.

LOGARITHMIC SINES AND TANGENTS.

42 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.82554	14	9.87107	11	9.95444	25	10.04556	60
1	9.82565	14	9.87096	11	9.95469	26	10.04531	59
2	9.82579	14	9.87085	12	9.95495	25	10.04505	58
3	9.82593	14	9.87073	11	9.95520	25	10.04480	57
4	9.82607	14	9.87062	12	9.95545	26	10.04455	56
5	9.82621	14	9.87050	11	9.95571	25	10.04429	55
6	9.82635	14	9.87039	11	9.95596	26	10.04404	54
7	9.82649	14	9.87027	12	9.95622	25	10.04378	53
8	9.82663	14	9.87016	11	9.95647	25	10.04353	52
9	9.82677	14	9.87005	12	9.95672	26	10.04328	51
10	9.82691	14	9.86993	11	9.95698	25	10.04202	50
11	9.82705	14	9.86982	12	9.95723	25	10.04277	49
12	9.82719	14	9.86970	11	9.95748	26	10.04252	48
13	9.82733	14	9.86959	12	9.95774	25	10.04226	47
14	9.82747	14	9.86947	11	9.95799	26	10.04201	46
15	9.82761	14	9.86936	12	9.95825	25	10.04175	45
16	9.82775	13	9.86924	11	9.95850	25	10.04150	44
17	9.82788	14	9.86913	11	9.95875	26	10.04125	43
18	9.82802	14	9.86902	12	9.95901	25	10.04099	42
19	9.82816	14	9.86890	11	9.95926	26	10.04074	41
20	9.82830	14	9.86879	12	9.95952	25	10.04048	40
21	9.82844	14	9.86867	12	9.95977	25	10.04023	39
22	9.82858	14	9.86855	11	9.96002	26	10.03998	38
23	9.82872	13	9.86844	12	9.96028	25	10.03972	37
24	9.82885	14	9.86832	11	9.96058	25	10.03947	36
25	9.82899	14	9.86821	12	9.96078	26	10.03922	35
26	9.82913	14	9.86809	11	9.96104	25	10.03896	34
27	9.82927	14	9.86798	12	9.96129	26	10.03871	33
28	9.82941	14	9.86786	11	9.96155	25	10.03845	32
29	9.82955	13	9.86775	12	9.96180	25	10.03820	31
30	9.82968	14	9.86763	11	9.96205	26	10.03795	30
31	9.82982	14	9.86752	12	9.96231	25	10.03769	29
32	9.82996	14	9.86740	12	9.96256	25	10.03744	28
33	9.83010	13	9.86728	11	9.96281	26	10.03719	27
34	9.83023	14	9.86717	12	9.96307	25	10.03693	26
35	9.83037	14	9.86705	11	9.96332	25	10.03668	25
36	9.83051	14	9.86694	12	9.96357	26	10.03643	24
37	9.83065	13	9.86682	12	9.96383	25	10.03617	23
38	9.83078	14	9.86670	11	9.96408	25	10.03592	22
39	9.82092	14	9.86659	12	9.96438	26	10.03567	21
40	9.83106	14	9.86647	12	9.96459	25	10.03541	20
41	9.83120	13	9.86635	11	9.96484	26	10.03516	19
42	9.83133	14	9.86624	12	9.96510	25	10.03490	18
43	9.83147	14	9.86612	12	9.96537	25	10.03465	17
44	9.83161	13	9.86600	11	9.96560	26	10.03440	16
45	9.83174	14	9.86589	12	9.96586	25	10.03414	15
46	9.83188	14	9.86577	12	9.96611	25	10.03389	14
47	9.83202	13	9.86565	11	9.96636	26	10.03364	13
48	9.83215	14	9.86554	12	9.96662	25	10.03338	12
49	9.83229	13	9.86542	12	9.96687	25	10.03313	11
50	9.83242	14	9.86530	12	9.96712	26	10.03288	10
51	9.83250	14	9.86518	11	9.96738	25	10.93262	9
52	9.83270	13	9.86507	12	9.96763	25	10.03237	8
53	9.83283	14	9.86495	12	9.96788	26	10.03212	7
54	9.83297	13	9.86483	11	9.96814	25	10.03186	6
55	9.83310	14	9.86472	12	9.96839	25	10.03161	5
56	9.83324	14	9.86460	12	9.96864	26	10.03136	4
57	9.83338	13	9.86448	12	9.96890	25	10.03110	3
58	9.83351	14	9.86436	11	9.96915	25	10.03085	2
59	9.83365	13	9.86425	12	9.96940	26	10.03060	1
60	9.83378		9.86413		9.96965		10.03034	0
	Cos		Sin.		Cot.		Tang.	

47 Degrees.

43 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.83378	14	9.86413	12	9.96966	25	10.03034	60
1	9.83392	13	9.86401	12	9.96991	25	10.03009	59
2	9.83405	14	9.86389	12	9.97016	26	10.02984	58
3	9.83419	13	9.86377	12	9.97042	25	10.02958	57
4	9.83432	14	9.86366	12	9.97067	25	10.02933	56
5	9.83416	13	9.86354	12	9.97092	26	10.02908	55
6	9.83459	14	9.86342	12	9.97118	25	10.02882	54
7	9.83473	13	9.86330	12	9.97143	25	10.02857	53
8	9.83486	14	9.86318	12	9.97168	25	10.02832	52
9	9.83500	13	9.86306	12	9.97193	26	10.02807	51
10	9.83513	14	9.86295	12	9.97219	25	10.02781	50
11	9.83527	13	9.86283	12	9.97244	25	10.02756	49
12	9.83540	14	9.86271	12	9.97269	26	10.02731	48
13	9.83554	13	9.86259	12	9.97295	25	10.02705	47
14	9.83567	14	9.86247	12	9.97320	25	10.02680	46
15	9.83581	13	9.86235	12	9.97345	26	10.02655	45
16	9.83594	14	9.86223	12	9.97371	25	10.02629	44
17	9.83608	13	9.86211	11	9.97396	25	10.02604	43
18	9.83621	13	9.86200	12	9.97421	26	10.02579	42
19	9.83634	14	9.86188	12	9.97447	25	10.02553	41
20	9.83648	13	9.86176	12	9.97472	25	10.02528	40
21	9.83661	13	9.86164	12	9.97497	26	10.02503	39
22	9.83674	14	9.86152	12	9.97523	25	10.02477	38
23	9.83688	14	9.86140	12	9.97548	25	10.02452	37
24	9.83701	14	9.86128	12	9.97573	25	10.02427	36
25	9.83715	13	9.86116	12	9.97598	26	10.02402	35
26	9.83728	13	9.86104	12	9.97624	25	10.02376	34
27	9.83741	14	9.86092	12	9.97649	25	10.02351	33
28	9.83755	13	9.86080	12	9.97674	26	10.02326	32
29	9.83768	13	9.86068	12	9.97700	25	10.02300	31
30	9.83781	14	9.86056	12	9.97725	25	10.02275	30
31	9.83795	13	9.86044	12	9.97750	26	10.02250	29
32	9.83808	13	9.86032	12	9.97776	25	10.02224	28
33	9.83821	13	9.86020	12	9.97801	25	10.02199	27
34	9.83834	14	9.86008	12	9.97826	25	10.02174	26
35	9.83848	13	9.85996	12	9.97851	26	10.02149	25
36	9.83861	13	9.85984	12	9.97877	25	10.02212	24
37	9.83874	13	9.85972	12	9.97902	25	10.02098	23
38	9.83887	14	9.85960	12	9.97927	26	10.02073	22
39	9.83901	13	9.85948	12	9.97953	25	10.02047	21
40	9.83914	13	9.85936	12	9.97978	25	10.02022	20
41	9.83927	13	9.85924	12	9.98003	26	10.01997	19
42	9.83940	14	9.85912	12	9.98029	25	10.01971	18
43	9.83954	13	9.85900	12	9.98054	25	10.01946	17
44	9.83967	13	9.85888	12	9.98079	25	10.01921	16
45	9.83980	13	9.85876	12	9.98101	26	10.01896	15
46	9.83993	13	9.85864	13	9.98130	25	10.01870	14
47	9.84006	14	9.85851	12	9.98155	25	10.01845	13
48	9.84020	13	9.85839	12	9.98180	26	10.01820	12
49	9.84033	13	9.85827	12	9.98206	25	10.01794	11
50	9.84046	13	9.85815	12	9.98231	25	10.01769	10
51	9.84059	13	9.85803	12	9.98256	25	10.01744	9
52	9.84072	13	9.85791	12	9.98281	26	10.01719	8
53	9.84085	13	9.85779	13	9.98307	25	10.01693	7
54	9.83098	14	9.85766	12	9.98332	25	10.01668	6
55	9.84112	13	9.85754	12	9.98357	26	10.01643	5
56	9.84125	13	9.85742	12	9.98383	25	10.01617	4
57	9.84138	13	9.85730	12	9.98408	25	10.01592	3
58	9.84151	13	9.85718	12	9.98433	25	10.01567	2
59	9.84164	13	9.85706	13	9.91458	26	10.01542	1
60	9.84177		9.85693		9.98484		10.01516	0
	Cos.		Sin		Cot.		Tang.	

46 Degrees.

LOGARITHMIC SINES AND TANGENTS.

44 Degrees.

′	Sin.	D.	Cos.	D.	Tang.	D.	Cot.	′
0	9.84177	13	9.85693	12	9.98484	25	10.01516	60
1	9.84190	13	9.85681	12	9.98509	25	10.01491	59
2	9.84203	13	9.85669	12	9.98534	26	10.01466	58
3	9.84216	13	9.85657	12	9.98560	25	10.01440	57
4	9.84229	13	9.85645	13	9.98585	25	10.01415	56
5	9.84242	13	9.85632	12	9.98610	25	10.01390	55
6	9.84255	14	9.85620	12	9.9863	26	10.01365	54
7	9.84269	13	9.85608	12	9.98661	25	10.01339	53
8	9.84282	13	9.85596	13	9.98686	25	10.01314	52
9	9.84295	13	6.85583	12	9.98711	26	10.01289	51
10	9.84308	13	9.85571	12	9.98737	25	10.01263	50
11	9.84321	13	9.85559	12	9.98762	25	10.01238	49
12	9.84334	13	9.85547	13	9.98787	25	10.01213	48
13	9.84347	13	9.85534	12	9.98812	26	10.01188	47
14	9.84360	13	9.85522	12	9.98838	25	10.01162	46
15	9.84373	12	9.85510	13	9.98863	25	10.01137	45
16	9.84385	13	9.85497	12	9.98888	25	10.01112	44
17	9.84398	13	9.85485	12	9.98913	26	10.01087	43
18	9.84411	13	9.85473	13	9.98939	25	10.01061	42
19	9.84424	13	9.85460	12	9.98964	25	10.01036	41
20	9.84437	13	9.85448	12	9.98989	26	10.01011	40
21	9.84450	13	9.85436	13	9.99015	25	10.00985	39
22	9.84463	13	9.85423	12	9.99040	25	10.00960	38
23	9.84476	13	9.85411	12	9.99065	25	10.00935	37
24	9.84489	13	9.85399	13	9.99090	26	10.00910	36
25	9.84502	13	9.85386	12	9.99116	25	10.00884	35
26	9.84515	13	9.85374	13	9.99141	25	10.00859	34
27	9.84528	12	9.85361	12	9.99166	25	10.00834	33
28	9.84540	13	9.85349	12	9.99191	26	10.00809	32
29	9.84553	13	9.85337	13	9.99217	25	10.00783	31
30	9.84566	13	9.85324	12	9.99242	25	10.00758	30
31	9.84579	13	9.85312	13	9.99267	26	10.00733	29
32	9.84592	13	9.85299	12	9.99293	25	10.00707	28
33	9.84605	13	9.85287	13	9.99318	25	10.00682	27
34	9.84618	12	9.85274	12	9.99343	25	10.00657	26
35	9.84630	13	9.85262	12	9.99368	26	10.00632	25
36	9.84643	13	9.85250	13	9.99394	25	10.00606	24
37	9.84656	13	9.85237	12	9.99419	25	10.00581	23
38	9.84669	13	6.85225	13	9.99444	25	10.00556	22
39	9.84682	12	9.85212	12	9.99469	26	10.00531	21
4	9.84694	13	9.85200	13	9.99495	25	10.00505	20
41	9.84707	13	9.85187	12	9.99520	25	10.00480	19
42	9.84720	13	9.85175	13	9.99545	25	10.00455	18
43	9.84733	12	9.85162	12	9.99570	26	10.00430	17
44	9.84745	13	9.85150	13	9.99596	25	10.00404	16
45	9.84758	13	9.85137	12	9.99621	25	10.00379	15
46	9.84771	13	9.85125	13	9.99646	26	10.00354	14
47	9.84784	12	9.85112	12	9.99672	25	10.00328	13
48	9.84796	13	9.85100	13	9.99697	25	10.00303	12
49	9.84809	13	9.85087	13	9.99722	25	10.00278	11
50	9.84822	13	9.85074	12	9.99747	26	10.00253	10
51	9.84835	12	9.85062	13	9.99773	25	10.00227	9
52	9.84847	13	9.85049	12	9.99798	25	10.00202	8
53	9.84860	13	9.85037	13	9.99823	25	10.00177	7
54	9.84873	12	9.85024	12	9.99848	26	10.00152	6
55	9.84885	13	9.85012	13	9.99874	25	10.00126	5
56	9.84898	13	9.84999	13	9.99899	25	10.00101	4
57	9.84911	12	9.84986	12	9.99924	25	10.00076	3
58	9.84923	13	9.84974	13	9.99949	26	10.00051	2
59	9.84936	13	9.84961	12	9.99975	25	10.00025	1
60	9.84949		9.84949		10.00000		10.00000	0
	Cos.		Sin.		Cot.		Tang.	

45 Degrees.

LOGARITHMIC, or Logistic Curve, is a name given to a curve whose ordinates are in geometrical progression, while its abscissæ are in arithmetical progression. Hence any abscissa is the logarithm of its corresponding ordinate. See Huygens' *Dissertatio de Causa Gravitatis*, where the principal properties of this curve are explained; Guido Grandi's *Demonstratio Theorematum Huygeneanorum circa Logisticam*, seu *Logarithmicam Lineam;* Emerson *on Curve lines*, and Baron Maseres' *Treatise on Trigonometry*.

LOGARITHMIC Sines. See our article on Arithmetic.

LOGARITHMIC Rule, Nicholson's. See Arithmetic.

LOGARITHMIC, or Logistic Spiral, is the name given to a spiral curve, having its origin in the circumference of a circle, and winding continually about its centre, without ever reaching it. The name of logarithmic is given to it, because it is constructed in such a manner, that if radii are drawn from the centre to the circumference of the circle, so as to intercept arches, (commencing from the origin of the curve,) verges in arithmetical progression, the portions of the radii intercepted between the spiral and the centre, will vary in geometrical progression. See Halley, *Phil. Trans.* 1695-6, No. 219, p. 202, where he has applied this curve to the division of the meridian lines in Mercator's Charts, and also the works quoted under Logarithmic Curves.

LOGIC.

Logic is the science which professes to teach the proper application of the mental faculties in all deductions of reasoning.

This science naturally divides itself into two parts: the first, comprehending a description and analysis of the mental faculties; the second, containing practical rules for their application in reasoning. To the first, we shall give the general name of *Pneumatology;* to the second, the already established name of *Dialectics.*

Part I. PNEUMATOLOGY.

Pneumatology is highly interesting as a branch of inductive philosophy. The mind, it is true, cannot be subjected to the crucible, nor changed, by any chemical process, into new forms and modifications; but by an accurate examination of its notions and feelings, we can ascertain how far they are consistent with known general principles, and how far they are sanctioned by the order and course of nature. It has been said, that this is *observation*, and not *experiment:* this, however, seems to be an attempt to establish a needless distinction. The man who carefully analyses his ideas and feelings, with a view to separate true from false impressions, performs an experiment as decidedly as the natural philosopher, who, by the change and apposition of different substances, *observes* the general laws of nature. There is nothing but observation in either case; there is no new creation; the object in both is to examine certain *phenomena*, and to see whether their existence, in their present form, be natural or artificial, real or imaginary: and the man who, by attention to his own mind, can rectify false associations, and teach others the important secret, performs a most important service to himself and the public.

But then, it is said, that no discoveries can be made in intellectual researches; that nobody ever dreams of being put in possession of a new sense, or of a faculty, different from those already felt and recognized by the generality of mankind. There is a fallacy in this argument, of which those who use it are not aware. It would certainly be rash to affirm, that we know the utmost limits of mental resources, and that no new views can be given of our faculties, which may contribute to our happiness and improvement. But, without searching for new faculties, who can pretend to say that he has acquired the full use and exercise of his mental resources? Is he exactly aware of the extent to which they may be carried, or of the objects to which they may be applied? Has he emancipated his mind from every false impression, and delivered his faculties from every prejudice which may impede their exertion, or obstruct his own happiness? Till he has done all this, he need not complain of want of novelty in the philosophy of mind: and when he views the subject in connection with these important ends, he can scarcely fail to perceive, that

> "The proper study of mankind is man."

In the philosophy of mind, indeed, there is not the same facility of putting the public in possession of the improvements of individuals as there is in the case of the physical sciences. Every improvement in the latter, instantly becomes public property; and it is no sooner announced, than every lover of science can make himself master of the whole process by which it was discovered; for he is led by the hand every inch of the way. The case is totally different in the philosophy of mind; in this science, the improvements made by one individual cannot be communicated to another, without a process of thinking almost as intense as that employed by the original discoverer; the mind merely perceives the goal, without discerning the distinct road that leads to it, whilst a thousand phantasies present themselves, which distract the mind with delusive prospects, and either induce it to stop short, or carry it on, fatigued, prejudiced, and disheartened, to its original aim. We can step almost at once into the discoveries of Newton; but we may almost despair of ever reaching the comprehension of Bacon: in the one case, the precise process is set before us; in the other, the object can only be attained by a fixed attention to the unembodied conceptions, and evanescent feelings of our own minds: a species of mental exertion more difficult than any that is employed in physical researches.

But the study of the human mind is neglected, chiefly on account of the misconceptions which men form respecting its object and end. Some of its most important results are displayed in unlearning false impressions, and in throwing off the dominion of prejudices, which we suck in almost with the nurse's milk, and which insensibly infect our notions, and consequently our characters and conduct.

> ——*Populumque falsis*
> *Dedocet uti*
> *Vocibus.*

The world, however, does not see the glory of such investigations. Any thing that promotes public prosperity, by pointing out new sources of wealth, or by directing industry into more profitable channels, is readily appreciated, and highly approved; whilst the studies which have for their object to rectify sentiment, to improve the inward taste, and regulate the rational faculties, are neglected, if not despised; and man becomes more and more agglutinated to the external world, from which it is the object of true philosophy to detach him.

It will probably be said, that we are here confounding ing moral with metaphysical studies, and practical results with intellectual operations. We are not confounding, but combining them; because we think they never should be separated, as the only legitimate object of the philosophy of mind, whatever form it may assume, is to correct the judgment, to improve the reason, to refine the taste, to sweep away the mists of error, and thus to meliorate the ordinary condition of human life.

It is not denied that these objects have sometimes been lost sight of, and that the faculties have often been wasted in an empty parade of talents, and in investigations which tend rather to dazzle than improve. We do not pretend to justify this abuse of ingenuity; nor do we contend for the utility of many of those intellectual researches to which the world has long looked up with reverence, but which have been exploded by the unfettered good sense of modern times. But amidst the general disinclination to mental philosophy, and whilst almost all the talent of the age is turned to physical researches, we may be allowed to hint, that there has been a greater waste of ingenuity, in absurd theories respecting some of the laws of nature, and in useless investigations into some minute properties of matter, during the last century, than has disgraced pneumatology for more than two hundred years: and the jarring, and perpetually changing opinions of physiologists and chemists, form a curious (it is not clear that we should say favourable) contrast to the uniformity of opinion which prevailed for so many ages, under the influence of Aristotelian preponderancy. Bacon had the honour of first throwing off the chains; and, as is the case in most revolutions, the human mind underwent a revulsion, which threw its feelings into an opposite direction, and produced a dislike of the authority which had so long controlled it. It passed from a rigid despotism to a licentious democracy; and, from the contemplation of its own resources, to the almost exclusive investigation of the properties of the material world.

Whilst we rejoice in the advancement of science in every shape and degree, we cannot help lamenting that the study of mind is so much neglected in the present day; and that a race of *minute* philosophers, whose researches are confined to retorts and crucibles, should have attempted, with too much success, to bring discredit on the sublimest studies that can occupy the attention of the human mind. It were to be wished that they would attend to the words of Bacon, whom they pretend to follow: *Contemplationes naturæ, et corporum in simplicitate sua, intellectum frangunt et comminuunt. Aph.* 57.

All the pleasures of imagination and taste, all the beauties of poetry, all the riches of eloquence, all the advantages of ethics, law, and politics, are branches of the philosophy of the human mind; and they are a thousand times more interesting, and more useful to society, than all the discoveries of mere science since the beginning of the world. In directing the attention of our readers to the subject of pneumatology, we shall, at least, not be deficient in zeal for the honour of the science; and we will venture to throw in our own independent contributions, with a view to enlarge its boundaries. Whether they be original or not, the reader may judge: they are at least unborrowed and unbiassed, either by studied conformity, or opposition to any preceding system.

In consequence of the perfect independence which we mean to preserve in the first part of this article, we may be expected to differ, in many respects, from some eminent pneumatologists who have favoured the world with their speculations. We have the misfortune to differ, in some important points, from a living author of deserved celebrity, for whose talents we entertain the sincerest respect. But we write not to oppose him, or to undermine his system; where our ideas coincide with his, we shall be proud of the sanction of his authority; and when we controvert any of his doctrines, it is only in self-defence, to counteract their weight, as militating against our own conclusions. Though studious to avoid error, we scarcely hope absolutely to attain this desirable object. On a subject of such difficulty and extent, it would be presumptuous to dogmatize, or to affirm that we have altogether escaped the influence of those *Idola*, which have erected their shrine in every breast, and have abstracted part of that homage which should have been offered undivided at the altar of truth. As we are not so anxious to establish a system as to excite enquiry, we shall consider our object in a great measure gained, if we can attract attention to a most elegant and interesting object of study.

Nihil est in intellectu, quod non fuit prius in sensu, is a maxim of the schools which remained undisputed, till the acuteness of modern metaphysicians began to suspect that it was either erroneous in its principle, or dangerous in its tendency. And, certainly, it is pretty obvious, that if there be no ideas in the mind, but such as have entered by the senses, there can be nothing there but the ideas of sensible objects; a notion which would undermine at once the foundations both of religion and morality. Locke extended the maxim of the schools, by laying down *sensation* and *reflection* as the origin of our knowledge; and even this extension of the maxim has been thought too limited: and Mr. Stewart, who has stated more clearly than any other the erroneous conclusions which may be built on Locke's doctrine, proposes to receive it with the following qualification; "that the first *occasions* on which our various faculties are exercised, and the elements of all our knowledge acquired, may be traced ultimately to our intercourse with sensible objects."

To us it appears, that even this qualification, or explanation, is not sufficient; and that we never can have a rational system of pneumatology, till more justice is done to the *original* sensations of our nature, and to certain feelings which are coeval with the existence of the human mind. According to the doctrine of Locke, even as qualified and adopted by Mr. Stewart, the mind derives all its first materials of thinking, and of sensation, from the external world. But this appears to be at least a questionable position. The feelings of pleasure and pain, of desire and passion, do not depend on the external world: it soon becomes, indeed, the principal means of their excitement; but they undoubtedly exist, and are felt in the mind, before it has formed any acquaintance with the material world. In short, they are born with us, and necessarily exist in a percipient mind. Thus, we are furnished by the constitution of our nature, not only with capabilities of knowledge, and proper organs for the attainment of it, but the very principles which impel to the acquisition of all knowledge, viz. the desire of pleasure, founded on the aversion to pain; and the very end for which all knowledge is acquired, viz. the consciousness of enjoyment, may, and we have no doubt actually do, exist in the mind, before it is solicited by the excitements of the external world.

We are very far, then, from considering the mind as a *tabula rasa;* it possesses (in its original constitution) instincts, feelings, and propensities, which put in motion the whole machinery of the human mind, and lead it, step by step, from want, weakness, and ignorance, to all the riches of moral and intellectual knowledge.

Locke, in his zeal to overturn the innate ideas of Descartes, overlooked, in a great measure, the powerful influence of the principles we have mentioned in the acquisition of knowledge. We have no wish to advocate the cause of those exploded notions which Locke has assailed with such a formidable array of arguments and learning. But we have no hesitation in avowing, that we think his zeal has carried him a great deal too far. His object was to show, that the principles of all our knowledge enter by the senses, and are afterwards formed by reflection, into various classes and compounds; and that from one or other of these two sources arises every idea that can enter the human mind. In conformity with this opinion, he has been at great pains to show that we brought no knowledge into the world with us; a point which he has laboured with needless anxiety, as scarcely any body in their sober senses would contend for more, than that man is born with capabilities of knowledge, and that his nature is so constituted, that in given circumstances, certain faculties, or certain feelings, will be evolved; a position which does not militate against Locke's leading idea respecting the origin of our knowledge. It was sufficient for his purpose to show, that these faculties or feelings are not evolved without excitement; that this excitement is produced by external objects, and communicated to the mind through the medium of the senses. It is really trifling with his readers to attempt to show that the ideas of *personal identity*, *of God*, *and of worship*, are not born with children. If any idea necessarily arises in the mind, in certain circumstances, that idea is *innate*, in the only intelligible sense of the word; it is at least *connatural*, as lord Shaftesbury terms it; who, in allusion to Locke's laboured argument on this subject, asks, with a sneer, "whether the *idea of women*, and what is sought after in women, be not learnt from a catechism," instead of resulting from the constitution of our nature; and whether there may not be a danger of a general depopulation, should the knowledge of this important idea be lost?

We have already said, that the mind has original sensations which do not proceed from the external world; and that it must be conscious of pleasure and pain, before it is acquainted with the existence of any thing but its own feelings. The senses gradually make it acquainted with the external world; it soon learns its dependence on it for enjoyment; for from the very beginning it sees that the gratification of all its wants lies *without itself;* and from this circumstance we may date its first acquaintance with the material world. Since we depend so much on the external world for existence and for happiness, it is of the utmost consequence that we learn to select such objects as are useful, and to avoid such as are hurtful. It is but a short way, indeed, that the unaided experience of mankind would carry them in determining what is proper, or what inexpedient: we learn more in a few years from the instructions of others, than insulated savages would acquire in centuries from their own experience. Still, however, the author of our nature has laid the foundation of this knowledge in the constitution of the human frame; and how much soever we may owe to education and instruction, yet it is not true that man is altogether the creature of circumstances, or that his habits and dispositions, likings and aversions, are casual, and the offspring of prejudice. For we find that each of the senses has specific objects of gratification, and that some things are chosen, and some rejected, some admired, and some disliked, the very first time they are presented, according as they gratify or offend one or other of the external senses. The eye, the ear, the taste, the smell, the touch, decide instantaneously whether the objects presented to them be agreeable or otherwise. Thus our natural senses carry us a considerable way in the acquisition of knowledge; and, as far as they go, render us independent of the results of experience. We dissent entirely, then, from that philosophy which makes the senses derive their impressions *wholly* from experience, and from the ascertained qualities of the objects presented to them. We contend that they pronounce, at once, *suo jure*, whether certain objects are agreeable or disagreeable, without any knowledge of their utility or hurtfulness. We lose a very beautiful argument for the benignity of the Deity, if we admit that the senses receive their impressions merely from recollection of the qualities of objects. It is, no doubt, an indication both of wisdom and goodness, that the mind is made capable of treasuring up, for the use of life, the experience which the senses convey. But it is better still, and shows a more deep laid plan for human happiness, when we find that the senses have original, independent impressions, and that these correspond, as they generally do, with the results of experience. We have thus a double security for our happiness; for we have the natural intimations of the senses, and the knowledge of facts, pointing to the same goal, and combining their results to teach us wisdom. In short, it is evident that the author of our nature has suited the external world to our senses, or our senses to it, by a necessary adaptation, so that the impressions which we receive are not casual and fortuitous, but arise necessarily, in given circumstances, from the faculties of our minds, and the constitution of the visible world.

The mind then is not so absolutely unfurnished as some have supposed; instincts are implanted in it, which lead it a certain length in the prosecution of enjoyment, the only stimulus to intellectual exertion. Appetites and desires are inherent in it; even Locke will admit these to be innate (Book i. ch. 4.): it has the idea of mind from its own conscious energies; it has the idea of something distinct from mind, by feeling its desires gratified by external objects; it has the idea of power, as soon as the child can emit voluntary cries. We say it has these ideas, and acts upon them, because they necessarily arise from the very first development of its faculties, although it may never entertain a philosophical speculation on the subject.

Such being the intellectual materials of the mind, it soon receives abundant food from the external world. As soon as experience makes us acquainted with the properties of the objects around us, we learn to know which of the senses they are most calculated to gratify; and, by a more extended experience, we learn what is best adapted to our general comfort and convenience. This knowledge is treasured up in the memory, which may be considered as a *continuous perception*; its province being to retain the impressions originally conveyed to the mind by perception. This is memory in its simplest form. We shall afterwards have occasion to display the treasures with which it enriches the understanding. The mind being thus furnished with impressions, conveyed originally by perception, and retained by memory, the will, or, (to use a new term, though we protest against the introduction of a new faculty,) the *desiderative* principle of our nature, born with us, and founded on our wants, is constantly at work, to combine these impressions in the form most pleasing to the fancy; or is employed in devising means to secure the recurrence of such as experience has shown to afford delight.

Can any thing be simpler, then, than the apparatus which the author of our nature has provided for the acquisition of knowledge, and the attainment of happiness? We see in man, a creature born with the feeling of wants, which cannot be gratified by his own resources. He receives his gratification from external objects; the use of his senses is, to bring these objects within his reach, and to decide on their qualities. Memory retains the knowledge thus acquired, and directs to the same objects, when a renewal of the gratification is desired; or should satiety arise, or the insufficiency of past gratifications be discovered, the will prompts to new experiments founded on the principle of analogy, or on inductive reasonings from what we have already observed and felt.

This is the origin of all our ideas of sensible objects; and when we consider what an immense variety of feelings is associated with these ideas, we see at once an ample fund of intellectual resources. But, are not different faculties necessary for the perception of ideas of a different description? What, for instance, have the ideas of God, of moral obligation, and the like, to do with the external senses? Or can any of the ideas which enter by the senses, or any combinations of these ideas, lead to the important conclusion that there is a God, who has fixed a law of moral obligation which his creatures are bound to obey? Locke supposes that they may; we think otherwise; and even Mr. Stewart's qualification of his doctrine does not remove our doubts. For we conceive that when the mind is considered merely as an intellectual machine, receiving and compounding impressions, (and in this light it is considered by most pneumatologists,) the result, at best, would be nothing more than descriptive poetry; and we should remain strangers to some of the most sublime and interesting feelings, which can affect the hopes and fears of rational beings.

But the mind never ought to be considered solely in its intellectual character, but as influenced by the active energies of the will; and by several important intimations, which are either co-existent with its faculties, or emanate from the constitution of its nature, rather than from the information of the senses; and it is chiefly to the unnatural disjunction which has been made between the intellectual phenomena, and those which depend more immediately on *volition*, that we are to ascribe the difficulties and absurdities which have vexed and disgraced mental philosophy. There is, no doubt, room for a distinction between these two classes of phenomena: but it is not of that exclusive nature which metaphysicians have generally supposed; for no faculty of the mind is absolutely independent of the will, if we except simple perception, and the simplest modifications of memory, which may be considered merely as perception at second hand. Taking the intellectual powers by themselves, that is, confining our observation merely to the ideas which enter by the senses, and are stored up in the memory, we certainly never would be able to account for many important ideas which find admission into the human mind. But when we consider that we obtain a great many original ideas, from the original feelings which lay the foundation of moral obligation, and that the will is actively employed in every exercise of the understanding, we shall find little difficulty in accounting for every idea, even the most sublime or abstract, that can enter the human mind.

The child, for instance, as soon as he can suck the breast which gives him nourishment, or open and shut his eyes in obedience to the volitions of his mind, knows that he has *power;* and with the idea of *power*, that of *causation* is inseparably connected. Here, then, are two *profound* ideas which have drawn volumes from philosophers, which every child acts upon from the moment he draws the breath of life; and which lead him unconsciously to the most important conclusions. He soon feels that his own power is not sufficient for the gratification of his wants: he considers supreme power for this purpose, to reside in his parents: and the spoiled child who covets the moon for a play-thing, and cries because he cannot obtain it, is perfectly satisfied that it is in the power of his parents to give it. The idea improves as he advances, till he acquires more accurate notions of the general power and resources of man. He is then as fully convinced that the phenomena of the visible universe are beyond the range of human power, as he was, at first, that the means of gratifying his wants lay beyond the sphere of his own body.

In this way he is led to the idea of a God, almost as naturally, or we may say necessarily, as he was at first to the idea of the external world. Locke's objections here are of no force. "Can it be thought," says he, "that the ideas men have of God, are the characters and marks of himself engraven in their minds, by his own finger, when we see that in the same country, under one and the same name, men have far different, nay, often contrary and inconsistent ideas and conceptions of him? Their agreeing in a name or sound will scarce prove an innate notion of him." Book i. ch. 4. 14. We are not talking of accurate and enlightened notions respecting the nature and attributes of God, but of the simple idea of his existence: and an infallible foundation is laid for this idea as soon as a man perceives that human power could not make the universe.

There can be no great distance between the idea of a God, and those of religious and moral obligation; for as soon as we admit the idea of a Creator, we must also admit that he is the author of those laws which regulate the external world, as well as the constitution of our nature. We feel that these laws ought to be obeyed; because obedience to them insures happiness, and transgression produces misery; and we must be convinced that the Being who appointed them is entitled to reverence, being evidently the arbiter of our destinies, and able to award pain or enjoyment. These points fall more properly to be illustrated under the head of *moral philosophy;* but they cannot be improper here, when we are treating of the origin of human knowledge; and they are introduced at present, with a view to show that not only the existence, qualities, and relations of external objects, are communicated to the mind by the simple apparatus of the senses; but that in the same source, along with the *original feelings* of our nature, a foundation is laid for all those principles which advance the moral dignity of man.

We have no use, then, for innate principles, as understood by Descartes, and combated by Locke; but this we contend for, that the human mind is so constituted in its own nature, and so adapted to the tenement which it inhabits, and to the constitution of the material world by which it is surrounded, that certain ideas *necessarily* arise in certain circumstances. That many important ideas are never evolved in some minds is no objection. Though some are born deaf or blind, and consequently can have no ideas of sound or colour, yet it cannot be argued from this defect, that these are not natural and unavoidable sensations when the senses are perfect. In the same manner, every idea that belongs to man as a sentient, rational, and moral being, must be evolved when he is placed in favourable circumstances.

It will be seen, however, from our preceding reasoning, that our opinion does not coincide with that of some of the Grecian philosophers, which has been embraced by several in modern times, viz, that certain *simple ideas* which cannot be traced to the external senses, nor to any modification of their intimations, necessarily arise in the mind by the exercise of reason. We do not, however, object to this opinion so much, because it is false, as because it is imperfect, and not necessary for accounting for the phenomena: for we hold, that the elements of all knowledge are laid in the constitution of our nature, and have their foundation in the intimations conveyed by the senses, or in those original feelings which excite and direct the active energies of the will. Mr. Stewart assents to the opinion of Socrates, "that it cannot be any of the powers of sense that compares the perceptions of all the senses, and apprehends the general affections of things." By *the general affections of things*, he means *identity*, *numbers*, *similitude*, *dissimilitude*, *equality*, *inequality*, καλον και αιχϱον: "an enumeration," says Mr. Stewart, "which is of itself sufficient to show, how very nearly his view of this subject approached to the conclusions which I have been endeavouring to establish concerning the origin of our knowledge." Now, to us it appears that this is making the process of thinking infinitely more operose than it ever was intended to be by nature. It seems impossible to doubt that several, at least, of the ideas specified in this enumeration, find access immediately to the mind without any process of reasoning, and without any peculiar *sense* provided by nature for their reception. Does not a man know, at once, and the very first time that different objects are presented to him, whether they be *similar* or *dissmilar*, *equal* or *unequal*? We shall have occasion to show that the perception of *analogy* and *relation* necessarily accompanies our first perceptions of things: and by adding these important ideas to the original stock of knowledge which nature furnishes, we shall find our mental resources vastly extended, and an explanation provided for many of those phenomena which have perplexed and bewildered philosophers.

Powers of the Human Mind.

The great object and end of philosophical researches is, to discover the *general* laws by which the various appearances of the universe are regulated. How has the name of Newton been immortalized, by applying the simple principle of gravitation, with which every child is familiar, to the explanation of terrestrial and celestial phenomena? What fame has Kelper acquired by unfolding those general laws which regulate all the planetary motions? The success of some eminent philosophers, in simplifying and generalizing the laws of nature, has never failed to be, in some measure, injurious to science, by inducing inferior minds to give an unwarrantable extent to their inductions; and to apply them injudiciously to elucidate unexplained phenomena. But, though fully aware of the errors into which many have been led, by attempting to generalize too much; and though satisfied that it is safer to rest in known facts, than to endeavour to simplify and explain them by unwarranted hypotheses, we are, nevertheless, inclined to think, that the *ultimate* principles of our nature are much fewer than some eminent modern philosophers have represented.

In physical science, almost every year is reducing the number of those principles which were formerly considered as ultimate and inexplicable. Arguing, *a priori*, from the simplicity of nature, we might expect the same process to take place in the philosophy of mind; unless the ultimate principles which regulate its operations have already been discovered: and we cannot but think it inauspicious to the progress of this science, when we daily see principles multiplied, and powers invented, which were never heard of before. The discoveries in physics consist in the extension and application of known principles to new phenomena, rather than in the invention of new laws. This has not, of late, been the method adopted in intellectual researches; and many who have, in other respects, deserved well of philosophy, have rendered the study of mind more complicated by a needless multiplication of powers and faculties. It should be remembered, that the mind is *one and indivisible*; and what have been called its different *faculties*, are nothing but the same energy directed to different subjects, and, on that account alone, designated by different names.

We do not think that the ablest, and most ingenious of our modern pneumatologists, are free from the charge of having given additional complexity to the study of mind; and it is to be lamented that they have been compelled to write, rather to demolish false theories, than to detail their own ideas, in the natural way in which they would have occurred to the mind, had it been left to its unfettered exercise. It is no doubt highly useful to remove absurdities, and to shake the foundation of pernicious opinions; but it is unfortunate that authors, so able to serve the cause of truth, and promote the interests of real science, should have wasted so much time and ingenuity in refuting doctrines which would, long ere now, have been forgotten, had they not been preserved in more valuable compositions. In these cases, we swallow the poison along with the antidote, or, as happens in modern cookery, we devour insipid or nauseous substances, merely on account of the condiments by which they are seasoned.

Our professed object is simplification. But, although it would certainly aid our researches, and assist our comprehension, could we explain the phenomena of mind on a few simple and universally recognized principles, yet it would not, in the smallest degree diminish our wonder at the mechanism, (we speak metaphorically) of the human mind. On the contrary, it will rather increase our astonishment to see such varied and wonderful results, arising from such simple and obvious principles; it will put us more completely in possession of those circumstances which put the mind in action; and will point out the means by which its energies may be excited or regulated. Yet still, after all, we shall deceive ourselves exceedingly, if we imagine that, by any simplification, we shall be able to comprehend the nature of the human mind. That which is most simple, is least susceptible of explanation; and there is no room left for any thing but astonishment and admiration, when once we have reached the last link in that vast chain which connects mind and matter with that great Being, whose nature is unsearcheable, and whose ways are past finding out.

We have already seen, that Locke lays down sensation and reflection as the sources of all our knowledge. His theory is captivating by its simplicity, and by the extensive application of which it is susceptible. It is chiefly defective in leaving out of view some important original intimations, which we have already stated as lying at the foundation both of morals and pneumatology. By sensation, he understands the effects produced on our minds through the medium of the external senses. The other grand source of knowledge, according to him, lies in those operations which the mind exercises over the materials acquired by sensation: to these operations, he gives the name of reflection. It is evident, that he allows no influence whatever to the sensations of pleasure and pain, of hunger and thirst, which are born with us, and which cannot be referred to any of the external senses. We consider these as the original hereditary property of the human mind, as the stock with which it commences the business of life; or rather as the stimulus which puts all its energies in action. The senses are merely given us as *instruments* to enable us to satisfy the demands of appetites inherent in our nature, to reach the pleasure which we desire, or to avoid the pain which we feel. It is true, indeed, that in the course of our experience, our senses make us acquainted with many pleasures, or present to us many objects of annoyance, which had no place in the original catalogue of our wants and wishes: yet man is born with the feeling of wants, and with the power of deriving pleasure from their gratification. Locke, then, is evidently wrong in referring pleasure and pain to sensation and reflection, in his limited acceptation of the first of these terms. We have no reason to doubt, that man is susceptible both of pleasure and pain before he leaves his mother's womb, and before his external senses have ever been called into exercise.

Descartes, whom it is now unfashionable to read, or quote as authority, seems to have had clearer views on this subject than most of the metaphysical writers who have come after him. Instead of *sensation*, he uses the word *perception*, including under it, both the ideas which the senses convey to the mind from external objects; and also certain sensations which he refers to the body, such as hunger, thirst, &c. and others which he refers to the mind, such as joy, anger, and the like. *Inter perceptiones hæc est differentia, quod quasdam referamus ad objecta externa quæ sensus nostros feriunt, alias ad nostrum corpus aut quasdam ejus partes, et denique alias ad nostram animam.* De Passionibus, prim. par. Art. 22.

There is not, perhaps, all the precision in this view of perception which may be desired by modern metaphysicians, who distinguish it from sensation and consciousness; it is used, however, with the same latitude of meaning by Locke; and we are surprised that he did not take it in this enlarged sense as the principal foundation of knowledge: had he done so, his essay would have been free from most of those objections which we have hitherto urged against it. Instead of this, however, he assumes *those sensations which result from the perception of sensible objects* as the great ground work of human knowledge; thus excluding some important feelings of which the mind is conscious, but which do not originate in the external senses.

We intend to use the word *perception* in the modern restricted sense, as referring solely to the qualities of external objects; whilst, at the same time, we wish never to lose sight of those original feelings, which form, we might almost say, the very basis of mind; feelings which may be perceived without any knowledge of the external world, and which would exist in a new-born child, though the external world were annihilated. The feelings of *pleasure* and *pain* do not, in the first instance, originate in the senses, and the organs of sense are given us, not that these feelings may be generated—for they are coeval with our existence as sentient beings—but that, by the apparatus of the senses, they may be expanded and improved, till we see the unlimited extent of mental resources, and the no less unlimited means of gratification and enjoyment.

Mr. Stewart lays down the following as acknowledged general laws which regulate our perceptions:

1. The object either immediately, or by means of some material medium, must make an impression on the organ.

2. By means of the organ, an impression is made on the nerves.

3. By means of the nerves, an impression is made on the brain.

The first of these we see no reason to dispute. We know that certain sensations are produced in our minds according to the impression made on the different organs of sense: But here our knowledge stops; all beyond this is physiological hypothesis; or, if founded on facts, they are anatomical facts, and cannot be serviceable in the investigation of mind, which would have been just as well understood though a human body had never been dissected. Descartes is less positive on this subject than his admirer Mr. Stewart, who is otherwise the most cautious of philosophers. In the treatise *De Passionibus* he says, "Perceptiones quæ referuntur ad res extra nos positas, producuntur (*saltem cum nostra opinio falsa non est*) ab objectis quæ excitando quosdam motus in organa sensuum externorum, excitant quoque nonnullos motus, opera nervorum, in cerebro, qui efficiunt ut anima illa sentiat." All this *may* be true; but it has no connection with the study of mind, which can be known only by its own conscious energies. In short, we must be careful how we combine metaphysics with physiology: It is an alliance which never can prosper; it will betray every one who trusts to it; for if mind be essentially different in its properties from matter, it can receive little elucidation from physical researches. It receives, indeed, many important impressions from *without*; but its powers are ascertained by the manner in which it is affected by these impressions, and not by investigating the qualities or habitudes of material objects.

Perception.

After these preliminary observations, we proceed to consider Perception as one of the grand inlets of knowledge.

Were man directed by infallible instinct, perception alone would be sufficient for all the purposes of life: it would present objects to his mind as they occurred in the course of nature, and instinct would tell him which to adopt, and which to reject. On this supposition there would be little need for memory to retain impressions, or to treasure up the results of experience; and there would be as little need for judgment to discriminate among the objects which solicited attention. Such, with slight exceptions, or inconsiderable variations, is the condition of the brute creation. But the instincts bestowed on man are few, and limited in their operations, being merely such as are necessary to the functions of vitality, but wholly insufficient for the purposes of knowledge:

and even in the rudest state of society, man owes infinitely more to example, or traditional information, than to the instinctive tendencies of his own nature. It is obviously necessary, then, that man should have some means of storing up his ideas, and accumulating his knowledge, otherwise he would be worse provided for than the lowest of the animal creation. He is, therefore, endowed with memory, which serves as the grand repository of knowledge, and which may almost be said to give him a species of omniscience, as it enables him to set before his mind every kind and degree of knowledge which has ever been presented to his senses, or been the object of his consciousness. Nay, when joined with perception and the active principle of the will, it almost gives a kind of ubiquity to his nature. It diffuses, as it were, his existence indefinitely over time and space; combining the past, the present, and the future, in his sensations, and connecting things near and remote in one conception.

We conclude, then, that in perception and memory we have the foundation of all the intellectual apparatus of the human mind; that they are the instruments in the hands of the will, by which it accomplishes the most important ends; and that all the diversified phenomena of the human mind may be explained by a reference to them. We do not undervalue the labours of those philosophers who have given certain designations to particular mental phenomena, nor are we anxious to alter the terminology which they have introduced. Every striking appearance in the operations of mind, or of external nature, will necessarily attract attention, and be characterized by a particular name. Thus we find that we are possessed of the power of forming new combinations out of the materials derived from perception, and treasured up in the memory; and as the results are often very striking, and more impressive than any thing we have ever witnessed in the arrangements of nature, we distinguish this power by the name of Imagination. In the same manner, our attention is fixed by the other capacities of our nature; and they have received the name of *faculties* of the mind, though they are only the diversified exhibition of the same principles. All this may do well enough for popular use, but it has a tendency to infect philosophy with false theories; and some who have been most forward in protesting against the influence of figurative language in philosophy, have grievously neglected this caution, by erecting mere figures of speech into faculties of the human understanding. As our business is with first principles, we shall endeavour, on the one hand, to cut off all superfluous appendages, and, on the other, to shew the extensive application of which those principles are capable, which we admit as the instruments of knowledge.

With regard to perception, we conceive, that by extending its province to its legitimate boundaries, we shall find that it conveys to us directly some most important informations, the origin of which has been sought for by philosophers in the multiplication of imaginary faculties. By perception the impressions made on any of the senses are conveyed to the mind; and it may be distinguished from sensation by this circumstance, that in perception, an impression being made on an organ of sense, the mind always has an idea of the *externality* of an exciting cause; whilst in sensation the mind is merely conscious of certain changes in the state of its feelings, which changes may take place, without any reference to external objects. Thus we have sensations of hunger, of thirst, of heat, or of cold, of pleasure, or of pain; some of which, experience teaches us to refer to external objects as their cause, but all of them may exist in the feelings of percipient beings, without any knowledge of the external world. At the same time, an important class of sensations arises from external objects; and, in many instances, these sensations are so intimately connected with the objects which produce them, that we confound the sensation with the exciting cause. Thus we apply the term heat both to the sensation, and to the property in bodies which produces it: we call sugar *sweet*, because it excites the sensation of *sweetness*; and, in the same manner, we give to most external objects, which produce strong feelings of pleasure, or of pain, of delight, or of disgust, the name of the sensation which they excite. It is in this quality that they are chiefly or solely interesting to us; and we do nothing more than adopt the usual practice in ordinary conversation, of giving the name of the *effect* to the cause which produces it: hence we talk of a *terrible monster*, because it excites in us emotions of terror. We never confound the sensation of hunger with any thing external, because we know no external object which produces it. If we talk of the *hungry grave*, we are sensible that we are merely employing a figure drawn from our own feelings. But other sensations of pleasure or pain are so invariably connected with external objects, that the one necessarily suggests the other; hence the same sign serves for both; and they thus become connected in our imaginations, so that it is often difficult to separate what our associations and habits have so powerfully combined.

In every case of sensation, *feeling* is implied; and a reference is made directly or indirectly to pleasure or to pain, to liking or aversion. But those accidents of matter, which lie at the foundation of mathematical science, are the objects of pure intellect, and have no immediate reference to the feelings of sentient beings. We cannot conceive of sounds, tastes, smells, colours, or even of the objects of touch, but as agreeable or otherwise. But no sensation of this kind can accompany the perception of *mere figure and extension*. These ideas are conveyed to the mind, without producing any emotions of those feelings which are connected with pleasure or pain; they give rise to a very distinct and important class of perceptions, and may be considered as drawing the line between passion and pure intellect.

We have already observed, that there are certain sensations which cannot be referred to any of the external senses. The most interesting sensations that can occupy the attention of animated beings, are those which produce pleasurable or disagreeable emotions; and the senses are not so much the instruments by which these emotions are primarily excited, as the means by which the stock of pleasure is augmented, or the importunities of pain removed. Nay, we have no doubt that these emotions may be felt in a very considerable degree, altogether without the instrumentality of those senses which are generally considered as the inlets of knowledge, as well as of every pleasant or painful sensation. Will it be denied, that a man deprived of sight, hearing, taste, and smell, is susceptible of pleasure or of pain? Abstract from him the remaining sense of touch, and will it be said that we thereby destroy his vitality, or his consciousness? We have reason to think that there are animals nearly, if not wholly, in this situation, destitute of every one of our senses, and yet susceptible of pleasure or of pain. These sensations, then, do not depend absolutely on the senses, which present modifications of them, rather than originally produce them: they have their foundation, we cannot tell how, in the nature of sentient beings, and the senses are given to amplify, vary, or remove them.

But, on the other hand, we see no reason to doubt that certain ideas are conveyed to the mind by means of perception, which have no reference to pleasure or pain, and which consequently can excite no *sensation*, in so far as that word implies *feeling*. It is, in fact, impossible to conceive that mere *figure* or *extension*, which are indispensable accessaries of every material substance, and without which matter is inconceivable, can have any reference to pleasure or pain. The idea of matter itself, which, next to that of mind, is the most important that can be the object of our faculties, is altogether unconnected with sensation in the sense in which we have understood the word. It merely gives the conviction of a substance distinct from mind; and the very conception of such a substance excludes the idea of sensation. Extension, figure, and some others, have been called *primary qualities* of matter; colour, sound, &c. have been called *secondary qualities*.

Locke had incautiously adopted the ancient theory of perception, and had said that the ideas of the primary qualities in bodies were resemblances of their prototypes, being certain images propagated from external bodies, which transmitted their *form* to the mind without their *matter*. On these principles, Berkeley undertook to prove the non-existence of matter; and Hume endeavoured to raise, on the same foundation, a system of universal scepticism. In justice to Berkeley, however, we must observe, that Hume's conclusions by no means necessarily follow from the principles which the former had laid down. The only point which they held in common, was the non-existence of matter; the conclusions which they deduced from it were, *toto cælo*, different: and Hume is as unlike Berkeley in philosophy, as he and Priestley are unlike Jonathan Edwards in theology, though that writer, in common with them, holds the doctrine of *necessity*, and denies the freedom of the human will: and Priestley, whilst he recommends his work as an unanswerable demonstration of his favourite doctrine, is careful to enter his protest against all the conclusions which Edwards has endeavoured to deduce from it. Hume has as effectually demonstrated his dissent from all Berkeley's wholesome conclusions, by adopting only that part of his system which could be perverted by misapplied ingenuity to the worst of purposes.

There can be no doubt that Berkeley's conclusion necessarily follows from Locke's premises; for if we can have no knowledge of any thing that has not a resemblance to our ideas, it follows of course that we can have no knowledge of any thing whose existence is independent of our perceptions. There is more ingenuity than novelty in this doctrine, of which Berkeley was by no means the inventor. It was maintained by the ancient Pyrrhonists, and by the Vedanti school among the Hindoos, though it is probable that Berkeley did not borrow it from either, but elaborated it from the resources of his own mind.[*] Dr. Reid answered the arguments of Berkeley and Hume, by shewing that the *ideal theory*, which they had borrowed from Locke, and he from more ancient metaphysicians, was entirely unsupported by evidence, and that the existence of matter ought to be received as an ultimate fact, of which we have as good evidence as we have for the objects of our consciousness. After all, if the question lay between the system of Berkeley, and that which attempts to explain the phenomena of thought and volition, by referring them to modifications of matter, there can be no doubt that the former is by far the most philosophical of the two: and Berkeley's triumph over the *materialists* whom he opposed is sufficiently complete, even after Reid has demolished the main pillar of his argument. His system is not only conceiveable, but possible. Its possibility is demonstrated by the phenomena of dreams, in which, without the instrumentality of the outward senses, and without the presence of material objects, the mind receives all the impressions which the senses usually transmit from the visible world. But it is absolutely inconceivable, that any modifications of matter can form a thinking substance. For not one of the properties of matter bear the smallest resemblance to thought: and the blind man, who compared scarlet colour to the sound of a trumpet, was probably much nearer the truth than that man would be, who should compare hardness, softness, figure, or extension, to thought or volition.

As, therefore, we are content to rest our belief in the existence of matter, on the grounds of its being an ultimate fact, which we are unable to explain, but compelled to admit, we would put our perception of the primary qualities of matter on the same footing, for they are co-existent in our conceptions with the idea of matter; or rather they form the only idea that we have of it.

But there are other ideas which arise from material substances besides those of the primary qualities, such as proportion, equality, resemblance, relation, analogy, and the like, which will be found to be of essential importance in the philosophy of mind. According to Locke and Stewart, these ideas must arise from a train of reasoning. We, on the contrary, maintain that there is no more reasoning employed in the perception of them, than there is in the perception of matter and its primary qualities. To discover all the relations which subsist among the various objects of nature, a very complicated process of reasoning may be necessary; but *relation*, *proportion*, and *resemblance*, are, in the first instance, distinct original objects of perception: we cannot examine matter by any of our senses without perceiving them. At the very same instant that perception makes us acquainted with the existence of external objects, it also makes us acquainted with some of their more obvious relations. When equal objects are presented, we see that they agree; when unequal, we see that they differ; and the mind never loses sight of this comparison of objects, which is suggested by its very first perceptions. A single object would leave an insulated, independent image on the mind; but the moment that another is presented, a comparison is instituted, and we are compelled to mark their agreement, or their difference. This is the first link in reasoning when the objects are not presented simultaneously: when they appear together, perception enables us to recognise their apparent relation to each other.

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[*] Any person may be satisfied, that Berkeley's notions respecting the non-existence of matter are not new, by consulting the most accessible history of philosophy which we possess, *Enfield's abridgment of Brucker*. In the account of the Pyrrhonic sect, collected from Sextus Empiricus, the following passage occurs: "The idea of body is incomprehensible; for it is said to consist of length, breadth, thickness, and a power of resistance: but these properties, considered in themselves, are nothing, and can only exist as qualities of body; and yet, if these be taken away, the whole idea of body is destroyed." The following quotation shews the doctrine still more clearly. Γινεται τοινυν κατ' αυτον, των οντων κριτηριον ὁ ανθρωπος· παντα γὰρ τα φαινομενα τοις ανθρωποις, και εςι· τα δε μηδενι των ανθρωπων φαινομενα, ουδε εςι. Sext. Emp. l. i. §. 219.

Thus, then, with the power of perceiving objects and their relations; with memory, which is only perception at second hand, to store up these intimations for future use, and with our natural wants and desires to put this machinery in motion, we trust we shall be able to account for all the intellectual phenomena of the human mind; and to show that all the other *faculties*, as they have been called, are only modifications of these simple principles. In fact, if we contemplate with more accuracy the simplicity of nature, and the uniformity of the laws by which all its parts are regulated, we shall see but little need for such a complication of powers and faculties as figure in some systems of pneumatology. As all nature is bound together by certain common qualities and relations, human knowledge will be found to consist chiefly, if not wholly, in comparing resemblances, or contrasting differences: and this is done with little trouble; for we perceive intuitively the agreement or disagreement of the objects presented to us: or when they come before the mind in succession, the impression retained by the memory enables us to institute a comparison, and pass a decision.

Here, then, the intellectual phenomena of the human mind seem to be reduced to principles sufficiently simple; and the most varied and complicated appearances receive an easy solution, on the ground that God has established analogies and relations among the objects of nature, and made us capable of perceiving and remembering them. These analogies and relations give a unity to creation, and connect together its innumerable parts, by sameness, or similarity of properties or use.

Had the objects around us been completely insulated and independent, the whole life of man would not have been sufficient to learn their names, their qualities, and their use. But, by the present constitution of things, we see an almost infinite variety combined by the most simple, yet extensive laws of analogy; and it is not easy to say whether we have most reason to admire the variety, or the uniformity which prevails through all the works of God. We thus see the facilities afforded us for the acquisition of knowledge. In general, we waste our admiration on the wonderful powers of the human mind, and view with exultation its powers and capacities. We consider it as a kind of sovereign autocrat, subjecting to its dominion, by its inherent power, the most reluctant porcesses of nature. But it would not be amiss to consider, that the mind reigns over subjects predisposed to obedience, and who voluntarily present themselves to its control. In other words, the subjects of human knowledge are so arranged, disposed, and connected, that they glide easily into the mind; being bound together by that *vinculum scientiarum* which links together the most dissimilar researches, and gives beauty and order to the system of nature.

It is this perception of relation and analogy which not only lies at the foundation of our intellectual attainments, but actually constitutes the principal intellectual apparatus of comparing, reasoning, and judging. It is, in fact, *abstraction*, which, when stripped of the mystery in which it has been invested by philosophers, will be found to amount to nothing more than the perception of the relations, agreement, or disagreement, which subsist among the objects of nature. When these relations are once perceived, or when one common quality is seen among a number of dissimilar substances, it is easy to consider that quality apart from any one of them, and to designate it by a particular name. This is then called an *abstract quality*, which, though it cannot be conceived as separated from substance altogether, yet may be conceived as separate from any particular substance.

We readily coincide in opinion with those philosophers who say that brutes do not reason, because they do not abstract. We are not sure that they have, even in the smallest degree, the perception of analogy, contrariety, and resemblance; and every thing in their habits which seems to approach to the province of reason, may probably be accounted for from education or imitation. (See observations on *Instinct*, art. Moral Philosophy.) We are not sure that a dog knows the difference between a large piece of meat and a small: we think it probable that mere *Proximity* would decide his choice. It is certain that a hen does not know the difference between her eggs and a piece of chalk; nor, if she has three chickens, does she know when one of them is abstracted. The lower animals are saved from the trouble of comparing and reasoning, as infallible instinct directs them at once to the proper objects of gratification.

With regard to the much agitated question between the nominalists and realists, neither party seems to have been right; and neither of them had an object in view worth contending for. General ideas are neither mere *names* nor *real entities*. They are relations and analogies which the mind perceives to exist among the objects of nature. Whiteness, for instance, were it perceived in one substance only, would be a particular name, and would indeed be the distinguishing attribute of the substance to which it belonged; but when it is found in many, it then becomes a character of relation, connecting different substances, and is as real as any relation can be. We are inclined to think, then, that the field which has hitherto been occupied by nominalists, realists, and conceptualists, might be successfully disputed by a new denomination; and were it worth while to take a side in an exploded and useless controversy, we would go along with the *relationists*, who have not, before this, been heard of in philosophy. There are real relations to which we give names; of real entities we can form no accurate conception. When we give a name to any thing, we merely tie together a certain number of qualities or conceptions, which we do not know to exist elsewhere in the same relations or proportions. A name, therefore, is merely a bundle of ideas, arranged in definite order and proportion. It is this order and proportion alone which the mind contemplates; and the substance, or complex idea, is known only by its *relation* to others, with which we are better acquainted.

Memory.

Having endeavoured to explain the power of perception, by defining its province, and pointing out its extensive influence on intellectual philosophy, we now proceed to consider *memory*, with its important modifications. We have already said, that we consider memory as a kind of continuous perception, or as perception at second hand. It records and preserves the impressions originally conveyed to the mind by perception. It may, therefore, be justly called the store-house of our ideas; and the processes of reasoning and judging are nothing more than efforts of the will, arranging, selecting, and comparing the materials treasured up in the memory. Perception extends merely to the objects immediately submitted to the senses; memory embraces all the impressions which have been made on the mind; and if we consider how little, at any one time, is under the cognisance of the senses, we shall see the imporance of that power which retains those impressions which would otherwise be evanescent, and enables us to take advantage of past experience for our future use. From this store the moralist draws his illustrations and his instances; from this the orator adduces examples to enforce his arguments; from this the imagination of the poet is furnished, and his most brilliant images are only recollections or combinations of what he has felt or seen. The philosopher, whose province it is to discriminate, classify, and arrange, derives the materials of his art from memory; and the accuracy of his inferences depends entirely on the accuracy of the original observation, and on the faithfulness with which memory has retained it.

It has often been asked, What constitutes genius? The answer to this question has generally leaned towards that favourite notion, that genius is a species of inspiration, an undefinable something, communicated to a favoured few by the special gift of heaven. But whilst we do not go the full length with those who maintain, that nature has been alike bountiful to all with regard to mental resources, we hesitate not to affirm, that every man has, to a certain degree, the elements of genius: and that those who stand pre-eminent above the rest, owe their distinction entirely to the acuteness of their perception, and the retentiveness of their memory.

That the external senses of all men are not alike susceptible in receiving impressions must be admitted; for the organs, in many instances, are either obtuse or defective, or some way or other obstructed in their exercise. In such cases, the impressions will be less vivid, and less easily acquired; they will, of course, be less firmly imprinted on the memory, and less readily recalled when needed. We conceive these to be indisputable facts; and they destroy at once the doctrine of an original equality among men in point of genius. But give a man acuteness of perception, along with a retentive memory, and you furnish him with all the constituents of genius. All beyond this is casual and adventitious; and the genius will take its bent and direction from the circumstances which most frequently, or most powerfully, solicit the attention, or interest the feelings.

A mysterious power, however, has here been brought into action, which has been thought to modify the exertions of genius, and in fact to regulate its degree, as well as to influence its direction. To this power philosophers have given the name of *association of ideas*; and it has generally been considered as a distinct original faculty. To us it appears to be only a very interesting modification of memory; and we shall endeavour to illustrate the phenomena which it exhibits, and explain the circumstances by which it is regulated.

When any object is presented to the senses, the mind, being taught by the general analogy of nature to expect that nothing should stand insulated and unconnected, instantly goes in search of analogous objects or facts, to clear its doubts, or confirm its conjectures. This is a process with which every one is familiar, who has paid the slightest attention to the operations of his own mind. It goes on with such rapidity that we are conscious of no effort. We have been so catechised in the school of association, by seeing a connected series of objects or events, united by the relations of cause and effect, or of time, place, or circumstances, that one object instantly suggests another; we unconsciously ransack our memory for analogous facts, which start in array with such rapidity, that we attend to nothing but that ceaseless flow of ideas which pass before the mind, and which seem to be conjured up by some process, of which we have neither knowledge or control. It may be illustrated by the rapidity with which the fingers run over the strings or holes of an instrument, to modulate the musical sounds which the mind suggests. There cannot be the least doubt, that in every shifting of the fingers there is an effort of memory; but we are quite unconscious of it after we are familiar with the instrument, and are astonished at the facility with which the fingers obey the impulse of the mind.

This process of association presents a vast variety of interesting phenomena, and has a most important influence both over the moral and intellectual habits of men. When the associations are formed according to the order of nature, and when they are separated from what is merely fanciful or accidental, they lead the mind to wisdom, to knowledge, and to science: when inaccurately observed, when blended with foreign subjects, or distorted by the influence of some predominant passion, they give rise to the most foolish, the most obstinate, and the most hurtful prejudices; and madness itself may be considered as little else than perverted associations.

This principle, faculty, or process, (for we will not quarrel about a name,) has, like every thing else which is curious, interesting, and important, been involved in needless mystery; for, as happens in a juggling trick, our attention has been directed to the astonishing results, without being permitted to witness the simplicity of the process by which they are brought about. Before any mystery can arise from the incessant sequence of ideas, it would be necessary to show that the mind does not always think, or to prove that its ideas may follow each other without any natural, adventitious, or imaginary principle of connection. But this is impossible. The mind, indeed, in a careless mood, is not very nice about combinations; it takes those which present themselves with least trouble; but, however absurd or fantastic they may appear, they must have some connection with each other. Now, if we do not actually *see* the connection between objects, which we never can do when they are merely passing through the mind in idea, there is no other way in which they can be presented to the intellect but by means of the memory. We are, therefore, disposed to consider the association of ideas as nothing else than an ordinary act of memory, sometimes running superficially over the most obvious connections, at other times more rigidly examining dependencies and relations.

If it should be asked, then, how the recollection of one event immediately suggests all its relations, we answer, that it is merely the memory recording what it has seen, and running over that connected order which has been presented by the course of nature, or by casual and artificial arrangements. Every object, and every event, is either the natural or artificial sign of something connected with it, and memory is the recorded history of these relations. If we consider how almost infinite these relations may become, from time, or place, or circumstances, or feelings, we may easily conceive how the memory may expatiate over this boundless field,

> "And find no end in wandering mazes lost."

According to this view of the subject, there is no occasion to specify the laws of *association*, as they have been called. It is easy to state the most ordinary principles of connection; but it is quite unnecessary, and perhaps unphilosophical, for it would be attempting to limit what is in fact indefinite. It is of no consequence whether the connection be natural, artificial, or casual; the power of memory to recollect the various circumstances which have accompanied the perception of any object, is quite sufficient to account for all the phenomena which arise out of the association of ideas; and there is an immense variety of feelings which become as powerful bonds of association as any of those circumstances which philosophers have assigned as the laws which regulate its combinations.

Instead, then, of talking of the laws of association, we would talk of the circumstances which tend most to assist or strengthen the memory. We see a great variety in this faculty; and we even hear of *different kinds* of memory. One person has a facility in retaining one species of facts which can have no permanent hold on the mind of another. A person who is accustomed to discriminate, and to separate objects from their accidents, who carefully observes the analogies of nature and the relations of things, will have a *philosophical memory*: and when any object is presented to his observation, after examining its visible qualities, he will endeavour to discover, from the treasures of his memory, its relation with others: he will then consider all that is known of its history; the uses to which it has been applied; the persons who have discovered its properties; and the time, place, and circumstances, in which these discoveries have been made.

Here an almost endless field is opened up for the excursions of the mind, over which it may roam at pleasure, whilst it retains with pertinacity every impression presented in this wide range of philosophical inquiry. The memory, in this instance, receives its chief aid from that analogy which subsists among the objects of nature, which leads it, step by step, to the temple of science, and to all the treasures of varied knowledge.

All the other varieties which occur in investigating the phenomena of memory may be accounted for, from the different tendency of different minds to generalize; or from the predominance of particular views and feelings. We have already said, that man is chiefly distinguished from the other creatures by the power which he possesses of discovering the relations of things: without this he would not be a rational being: but this power of discernment admits of almost infinite shades and degrees. One looks to the nature, tendency, and connections of things; another looks only to the surface, and knows of no relations but those of time, place, and circumstances. These are the principles by which facts, totally unconnected with each other, are nevertheless brought together, and associated by the accidental circumstances of having been once in each others company.

Such principles of association are, in fact, as necessary, though not so natural, as those which depend on analogy; or on similarity of properties, or of use. It is impossible to detach any object, or any event, from the inseparable concomitants of time, place, and circumstances: and they who cannot trace the more philosophical relations, direct the strength of their minds to the ordinary and unavoidable accompaniments of every perception, or event, viz. the time when, the place where, and the circumstances in which, it has been presented, and when any of these are brought before the mind, the event connected with them will be suggested at the same time.

Here, then, a bountiful compensation is made by the Author of nature, for those who are unable to take a connected and philosophical view of his works. They are furnished with principles of association, which serve to renew their past pleasures, and to enhance their present enjoyments: and though recollections of the past may sometimes produce painful sensations, yet, as happiness is undoubtedly more largely distributed than pain, they will be gainers on the whole: and the sum of their enjoyment may perhaps be superior to that of the philosophical inquirer. A philosophical memory is a dry register of knowledge: and in as far as it tends to overlook those associations which are the representatives of feeling, it has an effect to diminish the resources which contribute to human happiness. We have little need to spurn such auxiliaries; for though our comforts greatly outnumber our calamities, yet one misfortune outweighs, in our estimation, a thousand blessings.

It is astonishing how tenaciously some minds will retain dates, and unconnected facts; and how readily they can conjoin things which have no natural alliance. This does not proceed from any peculiarity in the memory; its office is to retain past impressions; and in this respect it acts uniformly and consistently. Its various modifications depend on particular habits, feelings, and affections: wherever these are deeply interested, the memory will retain a firm impression: the most stupid will not easily drop from their recollection the circumstances connected with a painful feeling. This appears to be of all others the most powerful principle of association. The brutes themselves are affected by it: it is the origin of all that fear, and caution, manifested by the most ferocious beasts of prey, who have become acquainted with the arts and power of man: and we have known a dog, who, having been severely struck by a blacksmith, retained ever afterwards an implacable animosity against every man who wore a leather apron. There is no reasoning here; it is merely a recollection of the simplest signs: and memory to this extent is absolutely necessary for the existence of every animal, whose safety depends on its own exertions. Instinct directs it to proper food, and to the means of multiplying its species; but it does not warn it of the dangers by which it is surrounded: these must be felt and remembered.

It requires a strong effort to recollect things which have no connection but juxta-position, or contiguity of place, as philosophers have chosen to denominate this principle of association. But when once an interest is excited, when fear, or the love of fame, or the hope of profit, influence the mind, all difficulties will vanish, and we will remember a string of barbarous unconnected words almost as easily as we remember the succession of objects in an agreeable landscape.

This application of the mind, which is produced by particular views and feelings, has, by modern philosophers, been exalted into a faculty, and denominated

Attention. But it has not a single feature about it which can give it any claim to such distinction. It merely indicates the application of the mind to some particular subject, in which its feelings are interested, or which have acquired an accidental importance. It often happens that an artificial interest must be created, in order that ideas which are useful, but not attractive, may lay hold of the mind. It is in this view, chiefly, that the advantages of attention come to be discovered: we are totally insensible to the exercise of it, when the object presented is sufficiently interesting to engross the mind: we then forget time, and every other accompaniment of sensation, and dwell exclusively and devotedly on one favourite idea. But when the subject is of such a nature that the mind is disposed to wander from it in search of more agreeable ideas, it then becomes necessary to call to our aid some considerations of profit, or of fame, to overcome the irksomeness of application.

When we are compelled to make an effort either to observe or remember, we then become conscious of that quality to which we give the name of attention, which is merely an artificial interest, given to objects destitute of natural attraction; at least, it is only when the attention is directed to such subjects that we are conscious of its exercise.

When, therefore, it is said that the different degrees of understanding, in different individuals, depend on the different degree of attention with which they have viewed facts, objects, and appearances, it is only saying, that they depend on the interest which is felt in observing and remembering the objects and facts presented to the senses or the understanding.

We have no objection then to give a name to a process productive of such important consequences, and Attention will do as well as any other: but we think it unphilosophical to introduce a new classification where there is scarcely a modification of exertion. All the rules which can be given for fixing the Attention are merely expedients for interesting the mind; and *attention* is the name given to the mental application which necessarily takes place in consequence of this occupation of the feelings.

Memory has usually, though we think without necessity, been considered as of two kinds, a capacity to retain, and a power to recall past impressions; this latter exhibition of the faculty has been called *reminiscence*. There seems to be no good grounds for the distinction; in the former case, the ideas present themselves spontaneously, or, at least, without any conscious effort to the mind; in the latter it sometimes requires a considerable effort in order to recall them. This apparent variety, however, does not present even a modification of the faculty. No man can conjure up a lost idea by an effort of memory: he must go patiently in search of it; he must endeavour to get hold of one allied to it; he must then examine its connections and bearings, that he may get into the tract where the idea lies which he is in search of, which will then occur as naturally as those which presented themselves without an effort. It is, in fact, not the idea which we have forgotten: the idea lies safely locked up in the memory, and will instantly appear as soon as we have removed the rubbish under which it lies concealed. Our forgetfulness then arises merely from a break in the chain which conducts us through the labyrinths of the ideal world; and when once the connection is restored, we stumble involuntarily on the idea which we had lost, and instantly recognize it as an old acquaintance.

In these observations respecting memory, we must appeal to our readers whether we have not, at the same time, been describing the process which takes place in what has been called the Association of ideas. The writers on this subject divide Association into two kinds, the first involuntary, or spontaneous, the second influenced by the will. They tell us that there is a constant current of ideas passing through the mind, all linked together by some mystical bond of union, which admits of no explanation, as it is an ultimate law in our nature. Let us not create unnecessary mysteries. We believe the mind always feels, or thinks: we suspect that a suspension of these functions would amount to a suspension of its existence: and we should doubt whether the mind could ever exercise its faculties again without a new creation, were they once completely dormant. And it is wisely ordered that our cogitations should not go on at random, but according to some regular order and arrangement. It is by this means alone that the will can exercise any control over the faculties, and employ them to discover and apply those stores of which it stands in need. We may see, then, how necessary it is that our ideas should flow in some regular order, and discoverable connection, that we may have some command over the information which we have received, and be able to apply it as exigencies may require.

That such is actually the case is a certain fact; but it is not ultimate and inexplicable: it is clearly referable to that order and analogy which God has established among his works, which are never presented to us insulated and alone, but linked together by certain relations which the mind easily perceives and retains. Thus, whilst the mind continues to think, it must think according to the order in which things are presented to it, or according to their relations and connections; and this is sufficient to account for all the phenomena arising from the association of ideas. In the whole process we can see nothing but memory running over the objects and relations which have been presented to the mind.

The circumstance which seems to have misled philosophers on this subject is probably this, that the train of association does not present any idea of past time, which is always thought to be implied in memory; but it is certainly no less distinctly implied in the association of ideas, which is nothing more than the recollected relations of objects, circumstances, and events. Nobody ever imagined that this supposed power gives any ideas, or suggests any relations which have not been presented to the mind before. Though memory must always refer to objects, or ideas which have already been before the mind, yet it does not always suggest the idea of past time: in fact, time must be left entirely out of view in considering mere relations. When the things about which our thoughts are conversant are of a singular nature, and seldom or never occur at any other period, *time* then becomes an important accessary, and is recorded with a particularity corresponding to the rarity, or supposed importance of the thing. But when we are considering relations which occur every day, and which are understood to fall in with the usual course of nature, *time* is left entirely out of view, and is wholly disregarded in the consideration of general ideas. Yet, however much the idea of time is sunk in the train of Association, it is certain that this process always relates to ideas which are past, but which are rendered universal and perpetual by the order and constitution of nature. When new combinations are suggested, we then suppose another power to be employed, and ascribe them to an effort of the Imagination.

Mr. Stewart has said (*Elem. of the Phil. of the Human Mind*, p. 134.) that Conception, which he ranks as a distinct power of the mind, implies no idea of time whatever; but this can only be from the circumstance already mentioned, that it is conversant about ideas, or relations which have no reference to time. The business of conception, according to Mr. Stewart, is to present us with an exact transcript of what we have felt or perceived. Now, in as far as conception relates to objects, or feelings which have already been presented to the mind, we cannot perceive in what it differs from the remembrance of past sensations or perceptions; and we should be glad to know the difference between a distinct recollection of past feelings, or occurrences, and the conception of them. In short, all our researches lead us irresistibly to this conclusion, that every thing immediately submitted to the senses is an object of perception; and every thing not so presented to the senses is an object of memory: that, of course, these are the only two faculties which the will employs to accomplish the gratification of its desires.

No mental process has a better claim to rank as a distinct faculty than imagination, which appears to be almost creative, and to produce results scarcely reducible within the narrow limits of that intellectual apparatus which we have assigned as the means and ground-work of knowledge. But let us not forget that the will is the great moving principle within the mind, and that according as its energies are directed, it gives a different complexion to results brought about by the same instruments. We would define imagination, then, to be the will working on the materials of memory; not satisfied with following the order prescribed by nature, or suggested by accident, it selects the parts of different conceptions, or objects of memory, to form a whole more pleasing, more terrible, or more awful, than has ever been presented in the ordinary course of nature. When, for instance, we wish to represent the terrible, we seldom find in one object, or on one occasion, all the circumstances necessary to produce the full effect; we therefore bring together all the circumstances of terror which our memory can furnish; we combine them according to the suggestions of the will, and then represent the effect which such a combination may naturally be expected to produce.

A very wide difference has been conceived to exist between imagination and reason: and instead of being connected by any natural alliance, they are generally supposed to be opposed to each other, both in their origin and in their exertions. Their origin, we believe to be the same; their exertions are differently directed. Reason is the will working on the memory, to discover the actual relations of things, and make them subservient to the use of life: imagination is the memory under the same influence, and directed to the same end, that is, to discover the relations of things; but it seeks not those which are most real or most natural; it looks for those which, by the aid of some associating principle, may be rendered most serviceable in producing a desired effect. The man who writes a piece of biography, who is careful to ascertain genuine facts, and to investigate real motives, employs his memory and his judgment. He who wishes to represent man, not as he is, but as he should be, or as the writer desires him to be, employs his memory in collecting the qualities which he has heard, or known, to be excellent, and employs his his fancy or imagination to combine them. The one writes a history; the other a novel.

Invention in experimental philosophy is nearly allied to imagination. It originates in a careful collection of facts, and an extended observation on the course of nature, in consequence of which, the philosopher anticipates certain results from the combination of known principles: thus far, it scarcely differs from the imagination of the poet, when by the application of ascertained facts, and principles in human nature, he calls our attention to results hitherto unobserved. The difference consists in this, that the philosopher can ascertain the accuracy of his anticipations by actual experiment, whilst the creations of the imagination can seldom or never be realized in the experience of human life. This distinction, however, did not exist in the infancy of science; imagination, in too many instances, supplied both facts and results, and reared a visionary fabric which amused the fancy, whilst it misled the reason, till it vanished at the touch of genuine philosophy.

Memory, in the form of reason, is chiefly conversant about the particulars of a particular case: in the shape of imagination, it dwells more on general ideas, which, by the order and analogy of nature, may seem to belong to the case in question. In both cases, however, the will is the agent, and the memory the instrument which is applied to different uses, according as circumstances require, or as volition directs.

Pope's celebrated lines, applicable to this subject, are to be taken with that allowance which is due to poetical philosophy:

——In the mind where memory prevails
The solid power of understanding fails;
Where beams of warm imagination play
The memory's soft figures melt away.

The first couplet can apply only to that species of memory which we have already described, which is exercised without any discrimination, and which combines with events all their accidental associations. It is only this exercise of memory which is hostile to the exertions of reason: Memory, under proper regulations, supplies reason with the means and materials of judging; in other words, it sets before the mind every thing connected with the subject under review, and enables it to decide in the way which experience (another product of memory) has found to be most useful.

It is true, however, that the exercise of the imagination may prove hurtful to the recollection of particular facts. When the mind is furnished with a set of ideas which it delights to contemplate, and which have derived, perhaps, an undue influence from accidental associations, it dwells on them with a preponderating fondness, and seeks, by varying their combinations, to vary its own enjoyments. A mind thus pre-occupied with the fascinating illusions of fancy, pays little attention to passing occurrences, or to any fact not immediately connected with its predominant feelings; they are either not noticed, or not remembered; and the mind finds more pleasure in the creation of aerial phantoms, than in the passive observation of actual facts. The person who habitually cherishes this state of mind verges on the precincts of insanity

The imagination implies an exertion of intellect not necessary for the existence, nor even, perhaps, for the comfort of life; for there are many in whom this power (as it is commonly called) is never evolved, who seem, nevertheless, to enjoy a reasonable degree of happiness. A refined imagination, however, is the luxury of intellect; and as necessarily arises out of a certain degree of mental cultivation, as the luxuries of life follow the acquisition of wealth and property. It is the flower, the blossom, the perfume, which imparts delight and pleasure, even though we do not taste the solid fruit; and in a well regulated imagination we possess some of the most elegant and rational enjoyments that life can afford. But it is an exercise of the mind almost too delicate to be either restrained or indulged; restraint is apt to destroy it, and convert into a sober exercise of reason; whilst indulgence is apt to destroy our happiness, and unfit us for the business of life. If we give way to the pleasing dreams of fancy, we will be the more easily annoyed by the sad realities of life; if we yield to the horrors of a gloomy imagination, the real pleasures of life will lose their relish, and we will be miserable in the midst of enjoyment. Thus, as the luxuries of life frequently become the bane of health, and as a palate accustomed to high seasoning will loathe ordinary fare, so a high wrought imagination will produce a sickly sensibility, and will shrink from the drudgery of research, and even from the exercise of sober reason.

There is, in this respect, a striking analogy between the body and the mind; whatever is stimulating and artificial is injurious to both; and the pleasure produced by high excitement is always succeeded by a corresponding langour. These facts may serve to reconcile us to that mediocrity of fortune and of feeling which is the ordinary lot of mortals; and may leave us in doubt, whether the high enjoyments which we desire in this world do not bring along with them at least a counterpoise of misery.

In endeavouring to explain the instruments which the mind employs in the acquisition of knowledge, we have been more anxious to remove the rubbish which false theories have heaped on the philosophy of mind, than desirous to establish a new hypothesis. Pneumatology appears abundantly simple, when divested of the mystery which ignorance and system have cast around it: we think it even elegant and attractive, when stript of those cumbersome and unnatural appendages which have been invented to make the multitude stare, but which only tend to render the subject absurd, unintelligible, and repulsive. Our principles are simply these, that in the instincts and feelings which are born with us, and in the powers of perception and memory which the author of our nature has bestowed upon us, we can find an ample explanation of the origin of every species of knowledge which can enter the human mind. These are the elements of pneumatology; and we have already endeavoured to show their extent and application. The subject will be still farther illustrated, by considering some interesting and important circumstances which modify the operation of our faculties; and the intimate analogy which subsists between the phenomena of mind and those of the material world demands our first attention.

Almost every writer on the subject of pneumatology has dwelt on the connection between mind and matter, which has, in general, been stated rather as a source of error than employed as a means of illustration. Hence, we are cautioned to be on our guard against external impressions; to exercise a jealous vigilance over the senses, and to consider their communications as hostile to intellectual exertion. The mind, it is said, must retreat within itself, and contemplate its own conscious energies, if it would wish to know the extent of its own powers and resources. But the only stores which the mind properly possesses within itself are blind instincts, and certain desires arising from the feeling of wants. All the other furniture of the mind is supplied from without, and, therefore, cannot be wholly detached from the objects which produced it. From this intimate connection with the material world, we may naturally expect that a great part of our conceptions will consist of material images, and that our language will be deeply infected with analogical metaphors drawn from the appearances in the visible world.

This, which, to others, has so often appeared a subject of regret, or has been denounced as a dangerous source of error, appears to us to lead the way to the true philosophy of the human mind: for, though mind and matter be essentially different, yet we shall find that they are connected by a law of analogy, which gives a kind of uniformity to the most opposite substances, and links together the material and the spiritual world. It is this analogy which forms that *mentis et rerum commercium*, which it was Bacon's object to elucidate; and which, though it sometimes misleads the philosophical enquirer, is of the greatest benefit to mankind at large, in heightening pleasure, and augmenting knowledge.

So strongly has this analogy been perceived by all nations, that the same words which denote the changes in matter are employed to mark the operations of mind; whilst, on the other hand, almost all those words which denote *desire*, *power*, and *feeling*, ideas peculiar to mind, are transferred to matter, to magnify or to illustrate its properties. We shall have occasion to show that language, in both these respects, is formed on strictly philosophical principles; and that this interchange of imagery tends equally to aid our conceptions, to heighten our feelings, and to enlarge the boundaries of our knowledge. But whilst we employ the connection between mind and matter, as the means of illustration, we wish it to be distinctly understood, that this connection exists merely in analogous processes, and not in any identity of substance.

The practice of explaining intellectual or moral phenomena, by analogies drawn from the material world, has been denounced, from high authority, as the chief cause of retardation in the philosophy of mind.* In one sense, we should not be much disposed to dissent from this decision. Were any one, for instance, to attempt to explain the phenomena of memory, by traces on sand, or impressions on wax, the theory can have no tendency but to mislead. But surely this author carries his antipathy to analogy and metaphor too far, when he wishes to exclude all illustrations drawn from this source as utterly injurious to the philosophy of mind. He repeatedly cautions his readers against supposing that there is any resemblance between the material object, from which a metaphorical or analogical expression is drawn, and the mental operation it is brought to illustrate; and he endeavours to account for the use of metaphorical language from the reluctance which men feel to coin new words, which induces them to give modifications of meanings to words already in use, rather than to form terms unheard of before. We hope it will appear, in the course of this discussion, that this is a very inadequate explanation of the subject; and we think we shall be able to demonstrate that mankind have formed metaphorical expressions, not so much from a wish to save words as to generalize ideas.

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* Stewart's *Elements of the Philosophy of the Human Mind*. Introduction

We are fully aware that the mode of illustration drawn from analogy has often been grossly abused. It has infected philosophy, and sometimes disgraced religion; and the injudicious way in which it has been managed by some of those who have been called *spiritualizing* writers, has often degraded the sublime subject which it was brought to illustrate. In consequence of this, philosophers have taken the alarm; and the present humour seems to be to denounce analogical illustrations as unphilosophical, and as the principal source of error in pneumatology. This is not altogether a new fancy; it is rather an old whim renewed: for it is a considerable time since it was proposed to denude the science of mind of every word which has a figurative meaning, or metaphorical origin, and to substitute an intellectual language, exclusively appropriated to mental operations.

The attempt is injudicious, absurd, and impracticable: it would deprive mind of its most powerful auxiliaries, by destroying or weakening those associations which aid our conceptions, and blend delight with instruction. It would subvert the principle of abstraction, itself, whose agency is so serviceable in the modern school of philosophy, and which must be founded on general views, and extensive analogies. All our knowledge is relative: we can form no correct idea of any one object without comparing it with others. The knowledge of individual objects is bald and insipid, when detached from the general order of nature: in that case, every fact would be in the situation of an anomaly, incapable of being reduced to plan or rule. The memory would be overwhelmed with a mass of incongruous facts; the mind would be a chaos of indigested materials. These inconveniencies are obviated, when we discover laws of analogy, and impose names which render them familiar to the understanding.

That this analogy is universally perceived, and has a powerful influence on the human mind, is admitted by all; that its influence is beneficial, except in moral reasoning, is almost universally denied; and we are not sure but we are the first who have brought it forward as an auxiliary in the science of pneumatology. In illustration of this subject, we shall, in the first place, give examples of that analogy which exists not only among the objects of nature, but between the processes in the material world and the operations of the human mind; and then we shall be prepared to shew its influence on our language and conceptions.

The sacred scriptures furnish numberless instances of beautiful analogical reasoning. All the parables are of this description; and without sheltering ourselves under the sacred authority on which they rest, we may appeal to any man's understanding, whether the moral, or inference which they convey, be not sufficiently obvious. Take, for example, the parable of the sower, (Mat. xiii. 3.) How aptly is the superficial Christian, who takes up his religion from some sudden impulse, without any settled principle, compared to a shallow soil on a barren rock, which at first gives a fair promise of a plentiful crop, but soon disappoints the expectations of the husbandman! Can any thing be more complete than the resemblance? And is not our conception of the invisible processes which take place within the mind powerfully aided, when these processes are described by analogous effects, cognisable by the senses? These may be called *moral analogies;* and Butler has shown how usefully they may be employed in elucidating the most important principles and doctrines. So strongly are we disposed to reason analogically, that in dreams, which, in spite of philosophy, we cannot wholly despise we seldom look for the literal accomplishment of what has passed in vision before the mind. We interpret it analogically, and consider it as the sign of some event, connected, by analogy, with the circumstances of our vision.

But, besides these moral analogies, there are others which have a more immediate reference to the philosophy of mind. The human body, for instance, advances slowly towards its perfection of strength and stature; the mind also advances slowly in moral and intellectual attainments; and we no more expect a premature evolution of mind, than we do an instantaneous enlargement of the body: we never look for *an old head on young shoulders.* Here, then, the progress of the mind might be illustrated by the growth of the body, with which it generally keeps pace; but as they are so intimately connected with each other, as almost to be identified, they are, on that account, seldom employed to explain each other's qualities. There is too much apparent sameness to afford illustration. To illustrate, therefore, the progress of mind, we look around us for instances of progressive advancement in objects which cannot be confounded with mind; and we delight to find a similar law connecting subjects esssentially dissimilar. These instances are furnished by the whole course of nature. The vegetable, the shrub, the tree, are all subject to this law, and afford many happy illustrations of the gradual development of the human mind, and some useful hints for the direction of its faculties.

These analogies are obvious to all mankind; and illustrations are drawn from them by the peasant, the poet, and the philosopher. The peasant enforces the necessity of early education, from the facility of *bending the twig when it is green;* the poet teaches *the young idea how to shoot;* and the philosopher does worse than trifle, if he rejects those illustrations which nature affords to aid our conceptions of mental operations. We believe it to be absolutely impossible to convey any idea of the operations of mind without them. The mind itself cannot be seen; its feelings can only be made known by the effects produced on external matter, or on the bodily form. By these visible effects we can perceive when the mind is affected by love, envy, or hatred: and when we wish to describe *past* emotions of this kind, we are persuaded that there is no other way of doing it pointed out by nature, but that of imitating their effects on the bodily organs, or of describing them by *analogous* appearances in the material world; as *rage*, for instance, which produces a convulsion of the features, may be described by a *storm* which agitates the surface of the deep.

When we say that it is impossible to convey any idea of mental emotions or operations, except by imitation or analogy, we must be understood as speaking of the first principles of our nature, and not of those conventional signs which mankind afterwards adopt, merely as abbreviations of the natural signs, to convey mental intelligence more rapidly, and more conveniently, than could be done by the exhibition of the natural passion, or by a tedious description of its effects. Words are, no doubt, the principal instruments in the improvement of the human race; not in consequence of any magical influence which they possess, but merely as convenient representatives of the visible effects of mental emotions, or as the signs of analogical descriptions of facts, feelings, or events.

Let us not, then, undervalue the illustrations drawn from analogy, but rather consider them as means provided by the bountiful author of our nature for smoothing the path to knowledge, and enforcing the obligations of duty; for we find examples and illustrations in every object around us; not a duty is enjoined, that is not illustrated by the order and course of nature, as well as sanctioned by positive command; not a difficulty occurs in the constitution of man, that has not its counterpart in the material world; and if we never murmur at the inexplicable phenomena of nature, why should we murmur when we meet with similar difficulties in the moral condition of man? Some, for instance, may be disposed to ask, why are we subjected to such a long immaturity, and to such a tedious discipline, before our bodily and mental powers reach their perfection? The illiterate might perhaps be puzzled by this question, and might think they had reason to complain, did they not see the same process obtain through the whole of organized nature. They are thus reconciled to their situation, without the necessity of profound reasoning, which it might not be convenient, or possible for the bulk of mankind to employ; and they no more repine that man is led from infancy to manhood through weakness, restraints, and dangers, than they would think of repining because the fruit is not produced ripe at once, without the process of germination, or the apparatus of blossoms.

In consequence of this general analogy among the objects of nature, and this mutual adaptation between mind and matter, we see the beauty of the system of the universe; as we perceive all the parts bearing a relation to each other, and all co-operating in the same grand design. Nothing stands insulated and alone; that which is weak in itself is strengthened by collateral facts; that which is obscure is illustrated by its connection with more obvious phenomena: and after we have found out a general order, we fancy we have discovered a law of nature, whereas we have only been tracing those analogies by which the Almighty has cemented the system of the universe.

A question may here occur, whether the mind is adapted to the constitution of nature, or this to the operations and habitudes of the mind. This is much the same as to inquire whether the body is made for the soul, or the soul for the body; and the answer in both cases must be the same, they are formed for each other; they form parts of one great plan devised by infinite wisdom. Without matter, mind could not possibly be what it is; without mind, as it is, matter perhaps could not exist.

——— *Quæ sit terræ mortalibus orbæ*
Forma?

In a certain sense, man himself is the *anima mundi*, not as being the *mens quæ agitat molem*, but as deriving sensations from the external world, as well as from the body which his soul inhabits. The energies of his soul are not only influenced, limited or controlled, by his bodily organs and appetites; he receives impressions from the whole world around him; and his mind is moulded to the general constitution of nature almost as much as it is to his bodily frame. Thus man lives as it were beyond himself; all nature is a kind of organ to supply sensitive or moral perceptions; and thus the world may be said to be the *sensorium* of man, and not of the deity; he is quite independent of it; it exists by his will, and by the ordinations of his wisdom; and that which is made and dependent never can influence the purposes of the omnipotent Creator. But, according to the present constitution of our nature, we can neither exist, nor think, without the external world.

From this intimate connection, then, which subsists between the mind and the external world, we need not be surprised if the nomenclature of our thoughts should be affected by it, and the words in which our ideas are embodied, should spring from a material origin. What are called analogical, or metaphorical expressions, are words marking conceptions which have been derived from the external world, or which can be illustrated and exemplified by some of its phenomena, or some of its qualities. These analogies are neither fanciful nor arbitrary. In many instances, indeed, they may be founded on imperfect knowledge, or inaccurate observation; and time and experience may teach us to lay aside associations which have been too hastily formed; but the principles on which analogies are formed have a foundation in the order of nature, and in the constitution of our own minds. As these principles are universal, we may expect every language to abound in figurative and metaphorical expressions; and this we find to be the case, although the different circumstances of different states must necessarily produce a considerable variety of associations and feelings, and consequently a variety in the figures and metaphors by which the mental operations are indicated. The arbitrary signs by which we communicate our thoughts make this variety appear greater than it really is; for these signs, when properly analysed, will be found, in general, to be nothing more than abbreviations, or representatives of figurative expressions.

In consequence of this intimate connection between mind and matter, we find these two substances, though essentially dissimilar in their nature, yet linked together by similar laws. We would wish this distinction always to be kept in view, for by losing sight of it the greatest confusion has frequently been introduced into philosophy; things totally dissimilar have been jumbled together, whilst things nearly allied have been violently divorced, from an absurd jealousy of a too intimate union. Must we say, because the reflection of light and the rebounding of a ball of ivory follow the same law, that the substances are therefore identical? According to our view of the subject, there is no necessity for such an inference; for we see, that there is often the most striking analogy where there is no identity of substance. We are not concerned, at present, to determine whether philosophers are right or wrong in deciding light to be material; we only say that they are not fully warranted to do so, merely from the ciscumstance of its following some of the laws of matter. We might as well say that the soul and the body are the same, because they follow a similar law in advancing towards maturity, and frequently also in sinking together into decay.

The best moral reasons may be assigned for the constitution of the mind being exactly what it is. Were man to arrive all at once at the perfection of his bodily frame, and the full strength of his appetites, but without the experience which is acquired by weakness, accidents and temptations, he would be totally unfit for the business of life; and his ripened passions, and uninformed understanding, would soon plunge him in vice or misery. Hence we may perceive, that if God created man at first perfect in his bodily form and faculties, there was an absolute necessity that he should be taught both knowledge and language by inspiration. Without this aid he would have been in the situation of a helpless idiot; confounded by the variety of objects which solicited his attention, and unacquainted with their properties, he would have soon fallen the victim of his own ignorance, and his life would have been terminated before he had learnt what was useful for his well-being.

We must now go through a tedious discipline in the school of experience; we must advance from weakness to strength, from ignorance to wisdom; no man can, *per saltum*, reach the pinnacle of knowledge; he might as well attempt to construct a dome without a foundation; his acquisitions must be painfully collected, carefully preserved, and judiciously arranged; and out of this store, which his wants and his ignorance have compelled him to accumulate, he produces the treasures of mental riches. That our knowledge may be sure, it must be slowly acquired. We not only know nothing at first, but we are apt to forget the little which we learn: before it obtains a firm hold on our mind it must be repeated a thousand times, and we must learn to act upon it as a practical principle by habit and use. It is thus that we acquire all the benefits of experience, and learn to contemplate the connection which subsists among the various objects by which we are surrounded; they appear at first detached and insulated, and the memory is overloaded with unconnected facts, till at last, being rendered familiar by use, and manageable, in consequence of a perceived connection, they become elements of knowledge, and the ground-work of future improvements; the mind can then glance over its accumulated stores with the quickness of intuition, and we are lost in astonishment at the inconceivable celerity of our thoughts, forgetting the tedious process by which the objects of knowledge have been rendered familiar to us, and the strong principle of connection which has been transferred to our ideas from the analogy of nature.

Thus, then, we perceive that the slow advancement of the human mind in knowledge is perfectly consistent with the circumstances of our nature, as it gives stability to our attainments, and by long practice gives us the perfect use of a few simple principles, which are found to be of almost universal application, and give a sort of unity to the seemingly discordant materials of human knowledge. It will be evident that the observations which have now been made, bear directly on the important subject of education: and if there be any truth in them, they condemn as contrary to the order and intention of nature, that forcing hot-bed system which modern innovation has introduced. In a few instances an extraordinary precocity of parts may produce wonderful effects in the way of attainments, which cannot but gratify the vanity of parents and teachers; but before the age of thirty all these effects disappear, and the patient drudge, who has been slowly gaining knowledge by experience, generally makes a more respectable figure in life, than the youth whose premature parts outran the slow progress of nature, but which, like blossoms out of season, are blighted before the fruit can be formed.

The whole system of nature is in perfect unison with this progress of the human mind. Trees, fruits, and vegetables, are subject to the same law, but for reasons totally different. From the physical constitution of plants and vegetables, and from the way in which they receive their nourishment, they can only advance gradually towards perfection; the ground has not strength to carry them to instantaneous maturity; the tree cannot supply the juices fast enough, instantly to concoct and ripen the fruit. Here, then, similar results arise from causes essentially dissimilar; and though no two things can be more unlike to each other, in their ultimate consequences, than the moral culture of the mind, and the physical growth of vegetables, yet they resemble each other in their slow advances towards maturity, and also in the accidents which promote or retard their progress: withhold nourishment, and they languish; apply an excessive stimulus, and they waste their strength in premature efforts. Virgil says of trees,

Sponte sua quæ se tollunt in luminis auras,
Infecunda quidem, sed læta et fortia surgunt.

As good an illustration as could be desired of a human being who grows up without culture, and who generally exhibits bodily strength and mental imbecility.

The bodies of all animals go through the same process of gradual augmentation in size and strength; and the final causes and intentional reasons, as far as we can ascertain them, are quite distinct from any that have yet been stated. Were animals to reach the full maturity of strength and stature instantaneously, or much quicker than they do at present, the earth could not afford subsistence to half the number which at present exist, and which enjoy the blessings of life as much, in their several progressive stages, as when they attain the perfection of their bodily frame. And besides, were the bodies of animals not to go through the various stages of helpnessness, imbecility, and danger, there would be none of those tender associations which bind together the heart of the parent and the offspring; they would thus be deprived of one source of enjoyment; and man would be denied the exemplification of one of the most important natural duties, which, if he were at present disposed to neglect, he would be admonished by the example of the whole animal creation around him.

Thus, then, we see a law of analogy linking together the most dissimilar objects in nature; and we thus, on the one hand, perceive a unity of design which bespeaks the contrivance of one superintending mind, and on the other, a harmony and mutual accommodation among the objects of nature, which bring them within the grasp of our faculties, and proclaim the wisdom and goodness of their Creator.

This law of *gradual* increase in strength and improvement, holds universally: we see it exemplified in the case of vegetables and of animals, of individuals and of nations, of morals, science, and religion. Nay, so much does it seem to form a feature in the economy of divine Providence, that, according to the sacred historian, there was in the work of creation itself, an infancy, progress, and perfection. Matter was first created, and then gradually arranged; the lowest species of animal life was first called into existence; every successive order of being rose in importance, till at last the climax was crowned with man, *sanctius his animal, mentisque capacius altæ.*

It may therefore be stated as a general law of nature, *Omnia orta augescunt, et aucta senescunt:* and we care not though it should be alleged that the mind itself goes through the same stages of progress and declension. As far as the senses are concerned this is often the case; they become less acute; the passions, which depend upon them, less clamorous; the memory less susceptible; the judgment more tardy. We make this admission without any apprehensions as to the conclusions which sceptics or materialists may deduce from it; for we are not contending for the immortality of the senses; we do not know that they can be of any use in another world; and the Scripture tells us, that *flesh and blood cannot inherit the kingdom of heaven.* But we are taught to believe, and reason confirms the suggestion, that the moral habits of the soul shall exist along with it; and these do not decline with the bodily senses: in many cases fatuity itself cannot extinguish them; they often become stronger as the body declines, and seem to gather strength from the weakness of the senses. A virtuous man does not cease to be virtuous because his senses have become less acute, or his reason less active, in consequence of age or bodily infirmity. Habit takes the place of reason, and becomes stronger in proportion as it is less solicited by the allurements of the senses. It is the same thing whether the qualities be good or bad. Dotage itself will not cure the miser of his avarice; the morbid affection clings to his soul, when his senses have lost their hold of almost every earthly object. What, then, although the scaffolding of the senses, to use the analogy of Butler, should be thrown down; the edifice is complete: the object for which the senses were given has been attained; and no argument against the soul's immortality can be deduced from their decay.

As language is not only employed as a medium of communication, but as an instrument of thought, an examination of the principles on which it is formed must occupy a conspicuous place in the investigation of mental phenomena; indeed it is doubtful whether the philosophy of language may not with equal propriety be denominated the philosophy of the human mind. Some remarks, then, on the structure of language are indispensable in all speculations on pneumatology; and we conceive that philosophical philology would go far to remove most of the mystery and obscurity which seems to hang over the operations of the human mind. To be a good astronomer, it is not perhaps necessary to understand the construction of the telescope, any more than it is necessary for correct vision to understand the structure of the eye. But language is more than the telescope of the mind: it is embodied thought; it is tangible ideas: it is mind made visible; it is the most correct representation of the human mind, in its present state of existence, as incorporated with matter, and employing visible signs to assist and explain its conceptions. We consider a good grammarian, then, (using the word in the most extended sense) to be synonymous with a sound philosopher. We shall, therefore, offer a few observations on this important subject, with a view to shew, in opposition to almost all pneumatologists, that analogical and metaphorical expressions are strictly philosophical in their origin, and of indispensable utility in the philosophy of the human mind.

Were we to view the objects of nature as detached and unconnected, we would assign to each a distinct and separate appellation. It is obvious, however, that this would create a vocabulary which no memory could contain; and the powers of the human mind would be wasted on a mere catalogue of names, instead of being directed to the qualities and properties of things. The author of our nature has relieved us from this unprofitable and intolerable labour, by binding the whole system of nature by analogies and relations, which are obvious to us every day, and rendered familiar by the experience of our whole lives; and the extension of our knowledge is, in general, nothing more than the extended application of those simple principles with which we have been acquainted from our earliest years. Here, then, is an evident facility afforded us for the attainment of knowledge; but we should forfeit all the advantages derivable from it, were we to affix distinct names to every modification of the original idea; for this would be an unnecessary accumulation of words, and an injudicious disjunction of objects and qualities nearly allied in nature. Wherever we observe striking relations and analogies among the objects of nature, the most obvious way of designating them is to preserve the same *radical*, varied by composition, or inflection, to denote the different modifications of meaning; and wherever the operations of mind can be described by any analogous appearance in the external world, it is natural to take the name of the sensible quality, and to apply it, *parce detorta*, to express the emotions of the mind.

The most important part of language consists in words invented to express the feelings of sentient beings these are almost all of a figurative, metaphorical, or analogical nature; and we do not believe it possible for language wholly to lose this character, and remain intelligible. The emotions of our mind must be communicated to others, either by a representation of their effects on the bodily frame, or by comparing them to some analogous appearances in nature. After the passion has once been delineated by either of these methods, we may substitute a conventional term as their representative; but this term is intelligible only in so far as it recalls to our minds the natural exhibition or description of the passion.

The origin of metaphorical language, then, is laid in the constitution of man; it is the first and most obvious way which nature points out to him to express his feelings; it arises not from the poverty of his invention, or the deficiency of his resources; nature teaches him to fly to it as the most powerful instrument, and most useful auxiliary, to express his sentiments and passions. It is, in fact, the principal pillar on which the structure of language rests.

It forms no part of our plan to contend for the accuracy of all those analogies and figures which are incorporated with language. They may, in many instances, be extremely fanciful or absurd; yet the principle on which they are formed is philosophical, if that be philosophy which is pointed out by the constitution of our nature, and, in a certain sense, we would be disposed to affirm that all figures are correct, even in their first formation; but this we maintain only in the same sense as we would affirm that the conceptions of the child are correct according to the extent of his knowledge.

Although, then, we would reckon it extremely preposterous to attempt to ascertain the present signification of words, by tracing them to the remote analogy which presented itself to the minds of the original contrivers, yet it is highly interesting to go through this process, and to trace a figurative word through its various modifications of meaning, with a view to mark the progress of human knowledge. We see the first rude idea gradually extricating itself from the erroneous notions with which it was at first combined, till it attains its present form and meaning; and in its several successive stages it indicates the extent of knowledge, or the existing state of manners. When we trace a word to its radical meaning, we only ascertain the conception entertained by its inventors; but it would be the height of absurdity to maintain that this conception is to be the measure and standard of our knowledge. The idea has been rectified by transmission through the minds of numberless individuals; in no stage of its progress, perhaps, has the change been sufficiently great to warrant the introduction of a new name; and it is certainly more commodious to correct the meaning of an old word, than to invent a new one to express the improved idea. Thus we retain the names of natural substances, though our knowledge of their properties is almost daily improving. The name, at first, expressed what we knew; and it is sufficient for the same purpose when our knowledge is doubled; it is like a string made of elastic materials, which will admit of a considerable addition to the parcel which it already surrounds, without being broken or overstretched.

But whilst we maintain that analogical or metaphorical language is perfectly philosophical in its origin, we hold it, at the same time, to be absurd in the extreme to found upon this any theory of sensation; or to suppose that mind resembles matter in substance, because its operations may be illustrated by visible appearances in the material world. On the contrary, we would assume this very fact as a proof of their being essentially different. It would be evidently improper in a materialist to employ metaphorical language, as, according to his creed, every metaphor would announce an identical proposition. Were the mind conceived to be material, it would be absurd to illustrate its sensations by the impulse of images, or to talk of its receiving impressions like wax or clay; as it would be absurd to illustrate the impulsive motion of a ball of ivory by that of a ball of wood. The things are exactly of the same kind, and therefore can afford no illustration of each other's properties. Every simile, to be good for any thing, must be drawn from subjects essentially dissimilar: and it is the generalizing effort of the mind, in extracting resemblances from things obviously different, which gives all its charms to an appropriate simile. The metaphorical language, then, universally employed by all nations, is, *prima facie*, a proof that mind and matter were conceived to be essentially different.

The world would have entertained a uniform and orthodox creed on this subject, had not philosophers disturbed the unanimity of opinion by their false refinements. The word *impulse*, or one conveying an equivalent idea, have been employed in various languages to denote the cause both of material motion and of mental exertion. All that the vulgar intended was to express a perceived analogy; and it is only by the mistake of philosophers in confounding resemblance with identity, that this analogy has been employed to explain the phenomena of perception; and to support the doctrine, that certain images, from external objects, actually *impinge* upon the mind.

Let philosophers, then, declaim as much as they please against the abuse of analogy and metaphor; it is but fair that they should attempt to rectify the errors which they themselves have introduced; but let them beware how they touch a principle, which serves as the chief medium of communication among rational beings, and which is so conducive both to pleasure and to knowledge. Mr. Stewart, than whom none is more vehement in their protestations against the use of metaphorical or analogical language in philosophy, counteracts his own doctrine, by an admission in his *Elements of the Philosophy of the Human Mind*, p. 126. "In the language of the rudest tribe we find words transferred from one subject to another, which indicate in the mind of the individual which first made the transference some perception of resemblance or of analogy. Such transferences can hardly be ascribed to accident; but may be considered as proofs that the analogies, which the philosopher afterwards points out between the objects which are distinguished by the same name, had been perceived by the inventors of language, although it is more than probable that they never expressed them in words, nor could even have explained them, had they been questioned on the subject." The only explanation that they would have thought of giving on the subject would have been that they perceived these analogies; and we would be glad to know what other explanation could be given by philosophers. We have already shown, that the perception of analogy is one of the original perceptions of our nature, and of course can admit of no explanation: we deny to philosophers the honour of the discovery: they have no more title to it than grammarians have to the invention of language: all that can be done, in either case, by the refinements of knowledge, is to arrange and methodize those materials which nature and necessity have pointed out for the use of man. Analogical resemblances are forced on our notice prior to any reasoning on the subject; and the only account which we can give of them is, that the author of nature has established them, and given us power to discern them.

A large class of figurative expressions arises out of this perception of analogy: these figures of speech are, in fact, merely the abridgments of analogical descriptions; and present to the mind at one view those illustrations of its feelings which are furnished by the order and course of nature. In every state of society they impart beauty and strength to language: they are like the venison and skins which feed and clothe the savage, and which in the highest state of refinement are converted into the means of luxury and magnificence. We hope, therefore, by analysing a little more particularly the method of their formation, to be able to throw some light on the philosophy of the human mind. We have already endeavoured to show that there is an analogy, or pre-established harmony, between the constitution of our minds and the order of external nature. In both cases certain effects and results are observed; in the case of mind by consciousness; in that of matter by perception. And why should there be any difficulty in comparing those effects which we feel by consciousness with those which we perceive by the organs of sense? In the following instances, the analogy between the effects on the mind and on visible nature is so strong that it is perceived at once; and the same words can be applied without confusion to both. In the case of obstinate stupidity, for example, though the utmost care be taken to *cultivate* the mind, yet it yields no *fruits* of useful improvement. It is impossible to announce this proposition without referring to the case of a barren field, which yields no sufficient crop to reward the labours of the husbandman. Horace had the same analogy in his eye, when he said,

> *Neglectis urenda filix innascitur agris ;*

Which he intends as a representation of the noxious passions which spring up in a neglected mind. In both cases certain effects are produced which diligence might have obviated; and in both, the effects resemble each other in their destructive consequences. Is there not in these instances an evident adaptation between the human mind and the constitution of nature ; an adaptation not of our contrivance, nor arising out of adventitious circumstances, but established by the wisdom of the Almighty, for the purposes of illustration, and for facilitating the acquisition of knowledge. When we see this adaptation between mental and material phenomena, we are drawn by philosophical principles, or rather by the constitution of our nature, to institute a comparison, and to illustrate the one only by the other. Such is the origin of an immense number of scripture analogies, which are introduced with powerful effect as moral illustrations ; as when it is said, *ye are the salt of the earth*, to intimate that as salt preserves substances from putrefaction, so Christian principles preserve the world from corruption.

Here, then, is an ample field for the introduction of figurative language, which, from what has been stated, will, we hope, appear to be both convenient in its application and philosophical in its origin. We can scarcely see the possibility of being misled by such language. It may be said that it makes us rest in fanciful analogies, instead of teaching us to explore the qualities of mind, or to investigate the laws of nature. In opposition to this, we affirm, that it directs us to the only genuine and profitable method of philosophizing, which consists in noticing the order, resemblances, and connections, established throughout the system of nature ; and by which we learn to arrange, classify, and generalize, both our moral feelings and the objects of our perception.

Besides, what would be gained by dismissing figurative words ? They approach a step nearer to the language of nature ; and even when we dismiss them, we substitute their signs, which derive meaning and importance only from being their representatives. Every thing that is the object of perception, in other words, all the objects of external nature, may, in the very first instance, be conveniently represented by arbitrary signs. But it is impossible thus to transmit the first knowledge of human feelings. They must, in the first instance, either be exhibited in actual representation ; and every narrator must be an actor in pantomime : or we must describe them by some analogous appearance in the natural world. *Rage* may be represented by the desolating storm ; and *mildness* by the gentle zephyr : *hatred* by the scowling cloud; and *benevolence* by the cheering light of heaven. When once this mode of communication is established, and we contend that it is the only one which nature points out for communicating the feelings and emotions of the human mind, more compendious and more artificial signs may be substituted ; but these are not the signs of the passions or emotions themselves, but of the figures and analogies by which they were first represented. They are, in short, only signs of signs : analogical figures are original indications.

When we see a person in a passion, we may give what name we please to the feeling by which he is affected ; but this name can be of no use when we attempt to describe the passion or feeling to a person who has never witnessed it. To make him comprehend our meaning, we must give an actual representation of the visible effects of the passion, or we must illustrate them by analogical descriptions, drawn from appearances in the visible world. Hence all words descriptive of human feelings, that are not of an analogical or metaphorical origin, or formed on the principle of onomatopæia, are only second hand representations of mental emotions. They are delegated by superiors possessd of higher powers, but less fit for the servile duties of life ; they are like plebeians without counsel, who execute the purposes of an intelligent aristocracy by which they are influenced.

If these observations are well founded, poetry and philosophy will not be so different in their origin as they are generally conceived to be : instead of being connected by any common principle, or by any natural alliance, they are supposed to be opposite and hostile to each other. But if it fall within the province of philosophy to mark the workings and affections of the human heart, and to explain them by appropriate illustrations, (and this surely is the philosophy of human nature,) then the true poet is a genuine philosopher ; and Homer, Virgil, and Milton, owe their fame to something else than the tinsel of imagery, or the melody of numbers. Poetry may be unfavourable to abstract metaphysics, and to artificial knowledge, but she is the handmaid of practical philosophy ; and no man ever reached the pathetic or sublime in poetry, who had not a philosophical mind, and a facility in associating appropriate analogies.

Though nothing can be more hostile to the philosophy of mind than an exclusive attention to some detached branch of physical science, yet we never shall be able to obtain a profitable knowledge of the operations of our own minds without attending to the general philosophy of nature. The greater part of our feelings are excited by impressions from without ; and when these feelings require to be corrected, or when it is necessary to escape from the influence of false associations, what remains for us but to compare our sensations with the exciting cause, to see whether they naturally arise from it ; or whether they are not rather *phantasmata*, and prejudices wholly unauthorized by the course of nature ? All those prejudices to which Bacon has given the phantastical names of *Idola tribus*, *Idola specus*, &c. arise from erroneous observation, our reason being blinded by our feelings or our prejudices. Now we know no way of correcting these prejudices, but by exhorting men to use their senses, that they may see that nature is against them. A man may meditate all his days on his prejudices, and instead of discovering their absurdity, may become more attached to them, unless he can be persuaded to open his eyes, and see that they are unauthorized either by general opinion, or by any facts in the history of society, or by any appearances in the external world. We laugh at that philosophy, then, which tells us that all our knowledge is from *without*, and yet forbids us to peep beyond the shell in which our souls are confined for information respecting the state of our perceptions and feelings. Our ears are perpetually stunned with the praises of Bacon for pointing out the true method of philosophising, whilst his professed admirers seem to lose sight entirely of the true scope of his philosophy, which is pointed out in the following sentences of the *Novum Organum*. " Cum nostra ratio interpretandi non mentis tantum et discursus, sed et rerum naturam intueatur ; ita mentem regimus, ut ad rerum naturam, se, aptis per omnia modis, applicare possit." And again: "His vero explicatis, ac postquam demum patuerit, quid rerum natura, quid mentis natura ferat; existimamus nos thalamum mentis et universi, pronuba divina bonitate, stravisse et ornasse." Our knowledge of the human mind will profit us little, unless we attend to the constitution of the external world, which influences so materially the train of our thoughts, and regulates, as we have already endeavoured to show, the phenomena of memory and association. Our ideas ought to be transcripts of the order of nature, or obvious deductions from those primary truths which nature forces upon us in a thousand different ways. To ascertain a man's own feelings, it is only necessary for him to examine minutely the impressions which his mind has received. But if he wishes to know whether his feelings are warrantably and legitimately deduced from adequate causes, or authorised by the end which he has in view, he must step beyond himself, and examine that order, and those relations, which the Almighty has established among his works, and which he has constituted as a rule to regulate the opinions and feelings of rational creatures. We may compare the mind to a watch, in which our wants and passions are the *mainspring*; the *machinery* which it acts upon lies in society, or in general nature; and the impressions resulting from this combined action are the *hands*, or indices, pointing to certain ends: if these mislead us, some of the wheels are wrong; and we must examine each, in its order, with the view to detect the defect.

We have already shown how much our conceptions and our language are influenced by this intimate connection with the external world: we have seen that an immense number of figurative expressions naturally, we may almost say necessarily, arise out of the perceived analogy between some of the operations of mind and the processes of nature: and a copious source of figurative language is also to be found in the intimate union of our souls with a material substance, and in the visible effects of mental emotions on the bodily frame. All the stronger passions, and deeper feelings of the soul, are displayed by a visible affection of the countenance, or by the motions and attitudes of the body. Hence, a painter pourtrays or personifies the passions, in the lineaments of the human countenance, or in the attiudes of the bodily frame, whilst the poet, or moral philosopher, are compelled to adopt the more tedious and less effectual process of actual description. No language can convey such a just representation of the agony of grief, or the ecstasy of joy, as the skilful exhibition of these feelings on the canvas; and hence we infer that the language which approaches nearest to painting is the most natural, as well as the most accurate representation of human feeling.

On the same principles, a play, well acted, must always produce infinitely more effect than the mere reading of it in the closet. When we read, there is always some effort required to form a proper conception of the scene; but the exhibition on the stage is a *continued picture*, and the language of the author is merely like so many *superscriptions*, to aid the conceptions of the spectator, and to teach him to apply the representation to some particular subject. We contend, then, that metaphor, which represents to the mind the visible effects of passions and emotions. accomplishes the object much more effectually than can be done by words which have not this tendency. For example, we see a person violently affected; but we can have no conception of his feelings till we have experienced them ourselves: nor can we know that our feelings are the same as his, except by comparing the *effects* which we witnessed in his case with those exhibited in our own. Having by this means ascertained the identity of the emotions, we may give them the name of *grief*, supposing this word to have no metaphorical meaning. In this case there would always be an effort of memory to recall the idea suggested by this word, as it is merely the sign of an unembodied feeling. How much more readily will the idea be suggested, if we suppose that the word *grief* is derived from *gravare*, to *depress*: it is then a description of one of the most obvious effects of grief: it presents, in short, a picture to the mind, because it represents an effect cognizable by our senses, and originally the object of perception; and we have been too well trained in the school of nature ever to mistake its meaning.

These observations may perhaps be sufficient to explain a circumstance, which some philosophers have remarked as a singularity in the constitution of the human mind. It has been thought strange that the mind should be able to recall the ideas of past emotions, without feeling afresh the emotions themselves. According to the view which we have given of the subject, the mind recalls nothing but a picture of the visible effects: for this is all that language represents; and language is, in every instance, used as an instrument of thought. The mind, indeed, is not altogether indifferent to the graphical sketches which are thus made to pass before it: it will view some with pleasure and some with dislike, as it would do in the case of any representation submitted immediately to the senses; but the sensation produced will be a mere transient feeling, and will pass away with the fleeting train of associations. When, however, the emotion has originally been of a very interesting nature, and when it is still interwoven with our feelings, or some way or other connected with our happiness, in that case, as soon as the picture is presented to the mind, the original emotion is reproduced, the train of thought is interrupted, the faculties are arrested, the feelings are concentrated in one point, and we resign ourselves afresh to the ecstasies of joy, or to the horrors of grief or remorse, which attended the original emotion.

We trust, then, it will appear, that figurative language is not the offspring of indolence, but dictated by nature and necessity, as the most obvious and most effectual method of transmitting human thought: it is pregnant with utility, and the supposed inconveniences attending it exist only in the imaginations of philosophers. Who was ever misled by hearing of the *pressure* of affliction, or of a *load* of grief? On the contrary, the expressions convey double information, not only acquainting us with the existence of grief, but describing at the same time its visible effects. Violent grief evidently produces a *prostration* of countenance, and a *relaxation* of the features; it depresses the bodily frame much in the same way as is done by the pressure of a heavy burthen. There is, therefore, both philosophy and accuracy of description in the words of the poet, when he says, *Sollicitis animis* ONUS *eximit*; and we feel the consolation, as well as perceive the beauty of the precept, which enjoins us "*to cast our* BURDEN *on the Lord*." On the same principle, we talk of a *flatness*, or *sinking*, or *heaviness* of the spirits, describing the mental feeling by the bodily affection. Or, if we wish to represent that fortitude of mind which resists the effects of sorrow, we talk of *bearing up* under misfortunes, to indicate that they have not produced a depressing influence on the mind.

On the other hand, when we are under the influence of opposite feelings, we talk of a *lightness* of spirits, because there is more springiness and elasticity of body; the muscles are more braced and firm, and the body actually appears lighter, because there is more strength to support it. When a man is successful, he lifts his head erect, and we say he is *elated;* which is literally true as to his body, whose appearance we consider as an infallible interpreter of the feelings of the mind. Conscious dignity, and real greatness of mind, have also a gait and attitude appropriated to them. *Et vera incessu patuit dea.* Pride is indicated by various metaphors, according to the effects which it produces on the bodily frame. When it produces a lowering and contraction of the eyebrows, it is called *superciliousness;* when it labours to enlarge the body, by way of indicating the greatness of the mind, it is called *inflation;* and its more ridiculous exhibitions are described by *puffing, strutting*, &c. In all these instances, we are merely describing the visible and sensible effects of mental emotions; and though language should lose its figurative character, or though familiar use should make us overlook the figurative nature of a great part of the words which we employ to describe our feelings and perceptions, yet we may rest assured that they are all originally either figures, or the signs of figures; and that mental emotions cannot be imparted and transmitted in any other way.

We hold, then, that all the words of which language is composed represent nothing, and can represent nothing, but sensible ideas: that those words which come, in course of time, to be considered as appropriated solely to mind, were originally only natural *indices* of the feelings or pictures of their visible effects. Were we ourselves alone concerned, were man solitary and independent of his species, he would have no use for language; he would indulge his own feelings without attending to their effects, or seeking the means of communicating them to others. But, since man is made not only gregarious, but absolutely dependent on society for the gratification of many of his wants, it was necessary that he should be possessed of some method of communication more perfect than the inarticulate cries of nature. And as nothing can be so interesting to man as the character of his own species, and the dispositions of those with whom he is compelled to associate, the Author of his nature has furnished him with the most ample means of information in this respect; and from the flexibility and susceptibility of his organs, he can indicate most perfectly every feeling which finds its way into the human heart. We by no means possess the same advantages with regard to the description of mere material objects. When a new substance occurs, we can only make it known by comparison, by drawings, or by actual specimens. There is here a considerable bar in the way of communication, and our attention is often fatigued, before we can form an accurate conception of some of the simplest objects of nature. A lady, our acquaintance, was one day reading with great earnestness the description of what she conceived to be an unknown animal, when, all at once, she burst into a fit of laughter, on discovering that it was her old acquaintance, the *lobster*. There are no obstacles of this kind to the communication of human feelings; for the most complex emotions can be indicated by an inflexion of the voice, or a modification of the features. We are thus most amply furnished with the language of sentiment, of passions, and emotions; and every feeling of the human heart can be expressed with the utmost facility, and in a way that cannot be misunderstood. Nature herself is the prompter, experience is the interpreter, and our eyes or our ears convey to the mind, with infallible certainty, a knowledge of the feelings and dispositions of others. Language, then, was not given to man, as has been satirically observed, *to help him to conceal his thoughts.* In the principles of its first formation, it is a natural index of human feeling.

It may perhaps be said, that though this language may be sufficient for communicating the emotions of the soul, yet it is altogether insufficient for describing the intellectual processes of the mind, such as cogitation, reflection, reasoning, judgment. We cannot help thinking that the signs which are sufficient to indicate the original emotion, and which are embodied in words descriptive of its appearance or qualities, must likewise be sufficient to indicate the *ideas* which are treasured up in the memory, and made the objects of thought. It is only the *signs* of emotions, and things, which are stored up in the memory; no man can remember an emotion; he only remembers what he did or said when under its influence; or he recollects the effects produced by it on himself or others; but the emotion itself he cannot remember; for the moment it is present to the mind, it is no longer memory but sensation.

On these accounts, we cannot join in the lamentations of those philosophers who mourn over the imperfections of language, and deplore its insufficiency for expressing the efforts of human thought. The progress of language is always proportioned to the extent of knowledge; and no man has a right to complain of it till he meets with a new idea, for which he cannot find an intelligible term. This will never be the case. We are conscious of no feelings which we cannot express, and of no mental operations which we cannot describe. Were it otherwise, it would be a reflection on the Author of our nature for having given to man, who lives in and for society, incommunicable ideas. We firmly believe that no idea finds its way into the mind that cannot be communicated; and wherever we find a difficulty to impart our feelings or opinions, it can only be when our conceptions are so obscure that we can not exhibit them in a definite form. The observation of the poet is applicable to the most recondite ideas which can enter the human mind:

> *Verbaque provisam rem non invita sequentur.*

All the difficulties and complaints on this subject arise from the squeamishness of authors to employ metaphorical language to the operations of mind. They wish to exhibit pure intellect, without the commixture of a single material idea; not considering that we can know nothing of mind, in so far, at least, as the communication of its feelings is concerned, but by its sensible effects, which are correctly described by words drawn from a material origin. When we consider, farther, that the soul is enclosed in a material tenement, and furnished with material organs, both for the reception and the exhibition of its feelings, we cannot be surprised that material signs are employed to indicate its operations.

We have thus pointed out two copious sources of figurative language; the one, arising from that analogy which subsists among the various objects of nature, and also between the operations of mind and some of the processes in the material world; the other, from the close connection between the soul and a material substance. As every emotion of the soul is indicated by some affection of the body, it was quite natural to employ the words which represent these visible effects as signs of the invisible emotion.

But mind is not alone indebted to matter for illustrations of its operations and feelings; it repays the obligation with interest; and a very large class of metaphors is drawn from mental affections, to illustrate, magnify, and adorn, the visible phenomena of nature. We thus invest dead matter with life, and deck out a new creation, by the transference of our feelings to objects devoid of all sensation. Hence, in many cases, we speak as metaphorically of matter as we do of mind; and the figures in general are used with not less propriety. Power, action, influence, &c. &c. when applied to matter, are all drawn from conscious operations of the mind. When we see certain changes produced on matter, we naturally ascribe them to some power or to some cause; but we can have no idea either of power or of cause but what we draw from our own minds, and from the effects produced by our conscious energies. By following out this argument, we might infer, with infallible certainty, the existence of an eternal mind, in which reside, essentially and primarily, power, wisdom, and goodness; for we see such an arrangement as clearly bespeaks the existence of these qualities; and we cannot conceive them to exist except in mind. They are entirely mental attributes; and when we apply them to inanimate objects we are merely attempting to explain a visible effect by a known cause; whilst, in describing mental operations, we reverse the process, and endeavour to explain the cause by the visible effects.

Poetry is chiefly indebted for its charms to the magic of transferring mental feelings to objects destitute of life and incapable of sensation. But the effect is only complete when the objects thus invested with life are natural signs of human feeling; or when they bear some resemblance to the visible effects produced on the human body by the influence of mental emotions. On this principle, Virgil says,

——— *Geminique menantur*
In cælum scopuli :

And Gray talks of the rock

———— Whose *haughty* brow
Frowns o'er old Conway's foaming tide.

These descriptions are drawn from the effects which defiance or pride produce on the human mien and countenance; they teach men *to carry the head high*, and to affect *to look down* on those whom they despise. Hence, a *high look* is denounced in scripture as an indication of pride.

From this effect of pride on the human form—from the distension and elevation which it produces—it is easy to transfer the epithet of *proud* to those natural objects, which are distinguished from others by their height or by their magnitude. Thus we talk of a *proud look* or a *proud mountain*, when either the man or the mountain raise their heads above their neighbours. All figures of this kind may be termed *emblematical*; they enter extensively into the composition of language, particularly the language of poetry.

Could men so far subdue their feelings that their natural indications never could be discerned, we hold it to be impossible to form a language capable of conveying any idea of mental operations or internal emotions. In all representations of feeling we describe nothing but the sensible effects; we employ, in short, a species of painting; and the power of language can in no case exceed, and indeed seldom equal, the magic of the pencil. In conformity with these principles, which are perfectly familiar, though but little attended to, a kind of *visible language* has been invented, which, without the medium of sound, exhibits to the eye the various emotions of the soul. This is done by appropriate gesticulation, and by allowing the passions their full power over the bodily organs. This language is employed with great readiness by those who have had the misfortune to be born deaf and dumb; and we have literally *seen* a conversation, which we understood almost as well as if the words had reached our ears; much better, it is probable, than could have been done, by merely hearing the words, without seeing the visible portraiture of the passions. This mode of communicating the feelings and emotions of the mind was studied with great accuracy in ancient Rome; and almost every school-boy is familiar with the story of the barbarian king, who is said to have asked one of the actors in the pantomime for his general interpreter.

All figurative words are called, in general, metaphors. But, without entering into the minute and needless distinctions of rhetoricians, to ascertain the classes and subdivisions to which they separately belong, we believe all the figures of speech may be reduced to three classes, *analogical*, *metaphorical*, (understanding by this all those words which describe causes by their effects, and *vice versa*,) and *emblematical*, comprehending similes, allegories, &c. and all words not belonging to one or other of these divisions are in themselves totally destitute of meaning. They are merely artificial signs, substituted, for the sake of abbreviation, for those which are natural; and they bear the same reference to ideas that ordinary writing does to hieroglyphical characters. We have no objection to allow them to be, in many instances, as useful for the transmission of thought, and the communication of sentiment, as figures in arithmetic, or signs in algebra, and we presume this is going nearly as far as the advocates for abstract terms can reasonably desire; at the same time, we maintain that they neither could exist, nor have a meaning, but as the representatives of more natural signs: and though, for general use, they may be more commodious, yet, in this instance, pleasure and convenience are, in some measure, disjoined. The conventional signs may be most convenient, but the natural ones afford the highest pleasure. It is easy to conceive that a *point* represents a tree, or a *line* a castle; but will any one affirm, that these arbitrary signs will give as much pleasure to the eye, or to the imagination, as the representation of the real objects.

These observations, we presume, will explain the source of that pleasure which men, in every state of society, have derived from poetry. It is because it approaches nearest to the language of nature; because it brings the natural signs of the emotions and passions constantly before the view, and thus gives less trouble to the imagination, the conception, or the memory. In this view of the subject we need not be surprised that poetry should be the first species of composition in every nation. In a certain state of society, we conceive that it would scarcely be possible for men to speak but in poetry; at least figurative language, which is the language of nature, would be employed, in all its shades and degrees, to express the conceptions of the mind, and the feelings of the soul. It is only when the intercourse of society becomes more extended, and when wants and arts are multiplied, that, in enlarging the vocabulary, it was found necessary to abbreviate the signs, and to connect them with the understanding rather than with the senses. For this purpose the memory was stored with a vast number of artificial signs, which, by long habit, it learns to apply with precision; and men become satisfied to sacrifice a little of the pleasure arising from natural description to the advantages of concise terms, and condensed narration.

Although, in the use of artificial signs, we must always refer to those which are natural, yet the mind learns to do this with such rapidity that the operation does not occupy the attention for a single instant; it hurries on to the conclusion, and it is only when it arrives at a wrong one, that it pauses to compare the signs with the several conceptions which have been produced. Something similar to this occurs in reading. In this process, we must see every letter, and know its power, and then divide them into syllables; we must then conceive the sounds, and the things signified by them; yet all this is done with an unconscious rapidity; and if, in our haste, we have assumed a wrong word, as frequently happens, by taking the first syllable for a sign of all the rest, when we reach the end of the sentence we perceive an incongruity of ideas, and are forced to turn back to correct our errors. This shows the vast rapidity with which the mind learns to think. The conceptions pass before the mind with the swiftness of lightning; the past, the present, and the future are blended together; and our feelings are often of such a kind, that no tense, invented by grammarians, can express them: for they are not only indefinite as to time, but they are totally independent of it, and give us some idea of the manner in which we shall feel *when time shall be no more*.

The observations which we have made on language will not only explain the source of that pleasure which we derive from poetry, but will also show what species of poetry is most calculated to yield delight. As poetry derives its power to please from its approaching nearest to the language of nature, simplicity, it will naturally be inferred, must form a leading feature in legitimate poetry. But though there must be simplicity in poetry—otherwise it cannot expect either to please or to live--yet it must be *poetic* simplicity; for every thing that is simple and natural is not necessarily poetry. Nothing can be more remote from poetry than that infantine simplicity which some writers have diffused over their works. They seem to think that they are speaking the language of nature, when, in fact, they are only speaking the language and sentiments of children. They ought to remember that the natural language of poetry is figure and metaphor; without this, it may be metre, or it may be rhyme, but it can have no pretensions to poetry.

But figurative expressions are not only the proper language of poetry, they are at all times natural and convenient vehicles for the communication of human thought; and the more figurative any language is, so much the better, provided the figures are properly selected, and judiciously applied. They give us, as it were, the picture, the visible representation, or the sensible effects of the feelings or objects which we wish to describe. In short, speech seems to have gone through nearly the same process as written language. They were both at first a kind of painting. Necessity would soon teach those who attempted to communicate their sentiments by the original form of writing, to abbreviate the cumbersome figures, which would otherwise crowd the skin or the canvas on which they wrote, and to substitute less unwieldy symbols in their place. Whether this would ever lead to the formation of alphabetical characters has been much disputed; certain it is, however, that the names of all the letters in the Hebrew alphabet, from which the names of our present alphabetical letters are derived, signify either animals, or interesting natural or artificial objects. There can be little doubt that the form of the letter is intended to represent the object from which it was named. We have only, then, to suppose that these figures of animals, or natural objects, were constituted representatives of sounds, (the first and most natural medium of communication,) to obtain the elements of an alphabet and of written language.

In our observations on language, we have considered it as resulting necessarily from the constitution of man. By maintaining this position, we do not interfere in the slightest degree with the question, whether language be of divine or human origin? All that we maintain is, that speech is an inseparable adjunct of human nature, and we neither affirm nor deny that a particular language was taught to the first man by inspiration. We have already said that man, created perfect in his bodily form, and with his appetites in full exercise, must have been taught knowledge by inspiration, otherwise he never would have lived to acquire it. He would soon have fallen the victim of his own inexperience. And there is no inconsistency in supposing that he was taught the elements of language as well as of knowledge. But, though he had not, he would not therefore have remained mute, nor would he have been unable to discover the means of communicating his knowledge. In the inflections of his voice, and the flexibility of his organs, he possesses the natural means of communicating his feelings and his knowledge. If language arises from any principle common to human nature, perhaps more uniformity might be expected among the various dialects spoken by the different tribes of men; and if a common principle prompts them to clothe their thoughts and feelings in words, it might be imagined that it would also direct them to the same sounds and the same signs. To a certain extent we find this actually to be the case. When objects are connected by a very obvious analogy, we often find them designated, among different nations, by words drawn from the same source, or described by the same figures, though different words are employed. There is a kind of natural language, founded on the inarticulate sounds which the various emotions of grief, joy, or terror, always produce. Similar words, arising from this source, are to be found among all nations; not transmitted by any intercourse of communication, but the spontaneous offspring of the feelings of nature.

Were we to say that language is the chief instrument of human improvement, and the principal means by which man maintains his superiority, we should not be suspected, by those who know the full import of this advantage, of lessening the dignity of human nature, or of bringing it down from that pre-eminence which it has always been conceived to enjoy. We are indebted to the discrimination of Homer, and to the flexibility of the Greek language, for an epithet which, when applied to man, is more descriptive, and more distinctive, than perhaps any definition which philosophers have proposed; and when we find him making such frequent use of the phrase, *articulate speaking men*, (Μεροπων ανθρωπων,) we perhaps shall not greatly err, if we regard him not merely as the father of poetry, but of philosophy.

It is not easy to point out the exact barrier which separates man from the lower animals; but though the boundary cannot be distinctly ascertained, there can be no doubt that it is eternal and insurmountable. It can, however, be attended with no bad consequences to admit, that though a brute never can encroach on the province of reason, except to a very limited extent, yet man, by very little effort, or rather by using no effort at all, may bring himself nearly to the level of the brutes in point of intelligence and virtue.

Some have ascribed the superiority of man over the other animals entirely to his bodily structure, and particularly to the conformation of the human hand. Hence Helvetius has said, that had the hoof of a horse been joined to the human arm, man would yet have been wandering in the woods. It would indeed be difficult to say what sort of figure man would have cut had he not been provided with hands; but we know what has taken place in the case of some animals better furnished with fingers even than man, who have, in fact, four hands in place of two: and if, by the proper exercise of these useful organs, man has left his woods and his tail behind him, how comes it that none of his long-tailed kindred have ever thought of following his example and participating in his comforts? Why are the ourang outang, and all the monkey tribes, still wandering in the woods? Or how comes it that domestication and human society have never been able to endow them with a portion of human reason? Man owes his superiority to the capabilities of his soul; and to facilitate the evolution of his faculties, God has given him a body *fearfully and wonderfully made*, and furnished him with organs admirably fitted to execute the purposes of the mind. Even his bodily form and features are nobler than those of the other animals. There is an expression in the human countenance of which we can scarcely observe a vestige in any of the brute creation. The blush of modesty, or of shame—the paleness of terror—the animation of joy dancing in the eye—the depression of grief, producing a monotonous relaxation of features—the pensive softness of love—together with a thousand other varied feelings, are all depicted on the human countenance, and give it an expression which both conveys intelligence, and suggests signs by which we are enabled to render such intelligence permanent and useful.

The lower animals, from the rigidity of their features, are completely disqualified for these delicate feelings. Almost the only feeling which it is necessary for them to express on their countenance, either for their own safety, or for the safety of others, is that of *rage* or *anger*; and they are abundantly furnished with organs for the exhibition of this quality, but we can scarcely read any other expression in their countenance. When a dog has occasion to fawn, he is put to the trouble of wagging his tail, and agitating his whole body. We would not infer from this that nature has been unkind to him; but rather that he is not intended for the exercise of a function which costs him so much trouble.

It is from this want of expression in the lower animals that we always feel less horror on seeing a dead brute than a dead human being. This may, no doubt, proceed in some measure from those associations which call to our recollection our own mortality, and point to the consummation which must annihilate our endearments. But it arises chiefly from the direct fact, that little change, comparatively speaking, is produced by death on the outward expression of the brute; whilst by this catastrophe, all those visible expressions of feeling which animate and lighten up the human countenance are completely extinguished. A salmon looks as well when dead as when alive; he only wants motion to make him equally interesting; and this defect may be counterbalanced by the consideration that he is most useful when dead. But when this change takes place in man every visible, emotion is gone for ever. The fire of the eye, the animation of hope, love, joy, which gave a divine expression to the human countenance, are all extinguished; and a cheerless universal blank, proclaims the departure of the actuating spirit.

All these advantages, however, which result from the structure of the human frame, are rather the means and instruments of improvement, than the sources of knowledge: and we must refer the acquisitions of man to some other principle than the perfection of his form or the flexibility of his features. We have already said, that the most prominent intellectual feature of man consists in the power which he possesses, of observing the analogies and connections which exist among the various phenomena of nature, which, in many instances, bear a resemblance to some of the operations of the human mind. We do not believe it possible to trace this power of perceiving relations, analogies, and resemblances, to any other source than the will of the Author of our nature, from whom we have it as an immediate gift. This gift is denied, or at least very partially imparted, to the lower animals; and the variations which occasionally occur in their instincts are rather to be ascribed to imitation, or to that degree of education to which almost all animals are susceptible, than to any process of reasoning. The power of perceiving the relations and dependencies of things may be said to be peculiar to man; and the necessity of his circumstances and the deficiency of his instincts compel him to record and remember them. Had an infallible instinct directed him at once to the objects best calculated to gratify the desires of his nature, and had these objects been placed before him in the same profusion in which they are furnished to some of the lower animals, in that case it is indeed probable that man would still have been wandering in the woods, a fierce, intractable savage: or perhaps the race would have been exterminated by some more powerful, or more ingenious beast of prey. But as man knows nothing but from experience, and as the knowledge which is to direct him in future must be collected from the past, he is compelled to treasure up his knowledge; and to compare, reason, and determine, when placed in circumstances which are not familiar to him.

This produces another peculiarity in the natural history of man: other animals live only to the present moment; and their feelings seem to be very little affected either by anticipation or retrospect. The case is altogether different with man; he lives not merely by present gratifications; his life is diffused, as it were, over the whole period of his existence; and the past and the future enter as much (and sometimes more) into the composition of his feelings as any present gratification or annoyance. No natural instinct tells him what is good : this he must learn by experience and observation. These again depend on *memory ;* and memory requires symbols, signs, and adventitious helps, to fix and arrest its otherwise fleeting impressions. Hence language was invented as a medium of communication, and letters were invented as a record of knowledge.

By oral and written language stability is given to human feelings and to human knowledge, which are thus transmitted from one generation to another, and enriched with continual accessions, till we are made to participate in the wisdom and experience of the remotest ages. The case is totally different with the other animals ; their feelings are insulated, transient, and incommunicable. Nor is it necessary that they should be communicated ; for the offspring is soon as wise as the parent. Each individual is indebted only to his own resources, which he has neither derived from the wisdom of his predecessors, nor can transmit to augment the knowledge of his posterity. But man owes least to himself. His character is formed by education and society ; and if we can trust the accounts which we have received of individuals who have been cut off in early infancy from the society of their species, they would appear, in these circumstances, to be much inferior to many of the brute creation. But man was never intended for such a situation ; and we think it is doubtful whether he has ever been found in it. He can only exist in society ; and in this situation only can he display the capabilities of his nature : for as a bee, when separated from the hive is said to lose its instincts, and to fall the helpless victim of the first contingency ; so man, if cut off from from the soceity of his species, would be equally helpless, and totally destitute of resources and of knowledge.

Thus whilst the most sagacious of the lower animals are guided by infallible instinct, which directs them immediately to the objects most conducive to their comfort, man appears at his birth the weakest, the most ignorant, and the most defenceless, of all the creatures which God has made. Yet in this natural helplessness is laid the foundation of the most exalted attainments. Were the wants of man supplied without the expense of labour or contrivance, he would never know the treasures which he possesses, nor be acquainted with those resources which he derives from the capabilities of his soul. *Necessity is the mother of invention :* and the sentiments of the poet are not more elegant than philosophical.

> —— *Pater ipse colendi*
> *Haud facilem viam esse voluit, primusque per arte*
> *Movit agros curis acuens mortalia corda ;*
> *Nec torpere gravi passus sua regna veterno.*
> *Ille malum virus serpentibus addidit atris,*
> *Prædari jussit lupos, pontumque moveri,*
> *Mellaque decussit foliis, ignemque removit,*
> *Et passim rivis currentia vina repressit,*
> *Ut varias usus meditando extunderet artes.*

Even in the philosophical view of the subject, then, we have no reason to complain of the deficiencies of our nature, or of the difficulties to which we are subjected : for, by the wise contrivance of the Author of nature, difficulties and defects are made the means of evolving our faculties, and stimulating our industry. But this arrangement of things appears still more important in a moral point of view, when considered as the means of repressing those evil passions and vicious habits, which infallibly arise out of indolence and inactivity. Thus the Almighty has made the same cause contribute both to our moral and intellectual improvement; and trains us, by the same means, to virtue and to knowledge. When it was said to man, *in the sweat of thy face shalt thou eat bread*, the sentence, like every other appointment proceeding from the same source, was marked by wisdom and goodness, as well as by justice ; for nothing less could have saved the human race from falling the victims of their own vices. It was not only a punishment for a past offence, but the most effectual preventive of crimes for the time to come.

PART II. DIALECTICS.

THE name of Aristotle is inseparably connected with the history of Dialectics. He claims the sole honour of the invention of syllogism; and his claims have been generally recognized : for, though the syllogistic mode of reasoning had been long known, and much practised before his time, yet he had the merit of reducing to a system those principles, which, till then, had lain as a chaos of indigested materials. The utility of his labours, indeed, has not only been disputed in modern times, but they have been denounced as the chief cause of retardation in the progressive march of the human intellect; yet no one ever doubted the ingenuity which planned, and the industry which perfected, a system which exerted a predominant influence over the human mind for so many ages.

Some curious circumstances have come to light, in consequence of our intimate connection with India, which tend to shake the credit of Aristotle as the inventor of syllogism. Father Pons, a French Jesuit, had informed the world that the doctrine of syllogisms was perfectly understood, and reduced to practice, by the modern Bramins in India. This account received confirmation from the testimony of Sir Willian Jones, who records, from a Mahometan historian, a singular tradition, current in the Panjab, that Callisthenes, among other curiosities which he transmitted to Aristotle, sent a Hindoo treatise on logic, in which the doctrine of syllogism was completely unfolded ; and that this formed the foundation of the Aristotelian logic.

We need not, perhaps, despair to see farther light cast on this curious subject. In the present state of our knowledge we can only conjecture ; and we confess, that if it shall appear indubitable that the Bramins are in possession of the syllogistic art, we would be inclined to conclude that Aristotle had borrowed from them, rather than they from him. We have no evidence that they ever availed themselves of European science ; and though the doctrines of Aristotle be quite current among the Mahometans of Hindostan, yet we can scarcely suppose that the Bramins would have borrowed from them, since they held both their usages and their doctrines in abhorrence.

But the system, by whomsoever raised, is a stupendous monument of misapplied ingenuity. It owed its attraction to its high pretensions; for there is something very imposing in the idea of possessing a rule by which we may measure the pretensions of every doctrine, and subject to the dominion of our own mind every branch of human knowledge. We need not be surprised, then, that Aristotle, the real or the supposed inventor of this art, should be regarded with veneration, and considered as a benefactor to the human race. It was long before mankind could be induced to doubt the infallibility of their guide, till at last his influence was shaken by experience of the inefficacy of his method for the discovery of truth, and by the splendid labours of a few, who dared to abandon the intellectual weapons of dialecticians, and trust their fame to a humble investigation of the laws of nature.

After all, we may perhaps be permitted to doubt, how far the Aristotelian philosophy exerted an unpropitious influence over the human intellect. Some centuries were, indeed, spent in trifling and logomachy; such also was the case before Aristotle was born. And we have always been inclined to think that the long immaturity of the world in knowledge, from the time of Aristotle till the revival of learning, may be accounted for from other causes than the predominant influence of the Aristotelian logic. It was not the cause why the Greeks and Romans stood still; it imposed no fetters on their researches; it gave no undue influence to their speculations; for it was, in fact, but little known among them. Ludovicus Vives says, that the writings of Aristotle were *named* rather than *read*, till the time of Alexander Aphrodisæus, who lived in the reign of Severus, and who brought them into reputation by the zeal and ability with which he illustrated them. It was not, however, till the middle ages, that the authority of Aristotle became paramount, and he was enthroned as the prince and legislator of dialecticians. It was than that the leisure of the school-men allowed them to attend to the subtilties of his doctrines, which they found admirable instruments for supporting the visionary distinctions which they had introduced both into philosophy and theology. Yet it was during these dark ages that the most useful discoveries were made in the most useful arts, and the foundation laid of that experimental philosophy which has brought us at last within the vestibule of the temple of science. The art of printing, rather than the genius of Bacon, gave an impulse to the human understanding which nothing could resist; and the reformation in religion, dismissing all veneration for prejudices, and all regard for usurped authority, completed the triumph, and left the mind at liberty to avail itself of those lights which a new course of investigation had thrown on the science and attainments of men.

It was precisely at this point that Bacon took the torch into his own hand; and, whilst he laid open to view the dreary wastes which had been supposed to be occupied by knowledge, he pointed out, at the same time, the plain delightful paths which lead to true science. So luminous was the view which he gave of the objects of human knowledge, and of the proper method of prosecuting them, that he is considered as the father of modern science; and it would be deemed almost as great heresy to question his pretensions now, as it would have been in the age of the school-men to doubt the supremacy of Aristotle. We trust we appreciate the merits of Bacon, even when we express our disgust at being stunned perpetually with the sound of the *Baconian Philosophy*. The great merit of Bacon is, that he has no *philosophy*, considering the word as implying a sect, or school, but that he teaches mankind the right method of philosophizing. And yet, much as he has done in this respect, we doubt whether the world would have been less advanced in science though he had never existed. Even without him the telescope would have done its office, and introduced us to the sublime discoveries in astronomy: Newton is the follower of Galileo and Kepler, not the disciple of Bacon. The microscope would have extended our knowledge of nature, by making us more intimately acquainted with the constitution of bodies. The air-pump, which arose out of the discoveries of Torricelli, would have made us acquainted with the philosophy of the atmosphere, and the vast variety of phenomena which depend on it. All these discoveries are totally unconnected with Bacon; and chemistry is almost the only branch of modern science which was in a state of complete stagnation when Bacon gave his writings to the world. All, then, that we would have missed by the non-appearance of Bacon, would have been the contemplation of a gigantic mind, seizing on those grand generalities which constitute universal science, and devising the canons by which the whole may be made subservient to the use of man. Bacon's was undoubtedly a mind of the first order; and he was fortunate in having arisen in circumstances which almost prevent the possibility of a rival; for before another such can appear, all that he has done must be forgotten, and the world must be placed exactly in the situation in which it was when he wrote,—a state of things which is not likely to occur during the existence of the present race of men.

The chief merit of Bacon consists in having swept away the rubbish which the followers of Aristotle had heaped on every subject of human knowledge, and in having laid the foundation of a rational logic. All that can be taught in the art of reasoning is, to guard against the errors which mislead the judgment; remove the sources of error, and there will be no difficulty in finding the fountain of truth. Our first concern, then, should be, that our conceptions on any subject be clear and distinct. Without this indispensable requisite, we wander, as it were, in a mist: no object is distinctly seen; we do not know in what direction we are going; and at last become so bewildered, that we scarcely know what point we would desire to reach. But though it is essentially necessary that our conceptions be clear and distinct, yet a great deal more is requisite to the formation of a legitimate conclusion; for it is obvious that we may reason right from wrong principles, and that our conceptions may be clear, though composed of incongruous materials. In this way, a madman often makes an acute logician, and reasons with closeness and accuracy from the false principles which he has assumed. In fact, we ought to be particularly jealous of very vivid impressions; the clearness of the conception prejudices us in their favour, we are unwilling to examine them rigidly, and we reluctantly reject what we can so clearly conceive.

In the investigation of truth, then, our attention must be constantly directed to the following particulars: 1. That the principles with which a writer or reasoner sets out be clearly stated. 2. That they be fairly warranted, by being deduced from ascertained facts. 3. That no extraneous idea, founded on the ambiguity of words, be admitted in the course of the discussion, to mislead the judgment, and divert it from the original scope of the argument. 4. That every link in the chain of reasoning be distinctly connected with each other, and the conclusion with the whole, so that the point to be proved may be fairly made out.

The difficulties of conducting an argument on these simple principles are immense. An author, when he begins a work, is not fully aware of the extent and bearings of the subject. New ideas crowd in upon him; and he is, every now and then, forced to extend or to qualify the definitions which he has already given. His principles are found, in many instances, to be at variance with the opinions or interests of certain classes or individuals, or perhaps with national prejudices and feelings. He must, therefore, attack the inveteracy of opinion, and endeavour to force or persuade mankind out of their favourite prejudices, by showing that they are inconsistent with reason, with public utility, and even with their own principles, where their interests are not concerned. Thus volumes arise out of a single maxim; and all the resources of genius, and all the treasures of knowledge, are put in requisition, to establish a fact founded in the nature of things, but controverted by the habits, interests, or prejudices of society.

It is evident, then, that Bacon performed a most essential service to logic, and to philosophy in general, by explaining the sources of error, and by pointing out the way in which they might be avoided. Yet even this was not altogether new ground, nor wholly unoccupied by preceding philosophers. Aristotle, in pointing out the different forms of sophisms, had laid open most of the sources of false reasoning: And though Bacon states his *idola*, as he calls them, to be chiefly applicable in the *interpretation of nature*, it is evident, that they are no less applicable in the philosophy of the human mind, and that they coincide in many instances with the sophisms of Aristotle. Bacon wished it to appear that they were only similar, not identidal; but he readily admits their general resemblance. *Doctrina enim de Idolis similiter se habet ad interpretationem naturæ, sicut doctrina de Sophisticis Elenchis ad Dialecticam vulgarem.* As we believe that the detection of error is the principal step in the discovery of truth, we shall give a short analysis of the labours of Bacon and of Aristotle, in investigating the causes of false reasoning.

Bacon arranged the sources of error under four heads, to which he gave the fanciful names of *Idola*, as if they were so many false divinities or idols, at whose shrine reason had prostrated its powers. He distinguished them by the names of *Idola Tribus*, *Idola Specus*, *Idola Fori*, and *Idola Theatri:* the first, arising from the general nature of man; the second, from the situations and circumstances of individuals; the third, from the intercourse of society and the imperfections of language; and the fourth, from the speculations and systems of philosophers.

I. The *Idola Tribus* have their origin in the very nature of the human mind, and arise either out of the uniformity of its substance, or its pre-occupation by some favourite ideas, or the limitation of its faculties, or its restlessness in pressing forward to ultimate principles, or the infection which it receives from the influence of the passions, or the fallacies of the senses, or the manner in which it has received its impressions.

1. With regard to the first particular, which Bacon terms the *æqualitas substantiæ spiritus humani*,* he observes, that the mind has a general tendency to abstract and generalize, and to seek regularity and uniformity in the works of nature. This, which may lead to true philosophy, is often the cause of much error: for, in consequence of this tendency, incidental appearances are instantly referred to some general law, and anomalies are reduced to the order of nature: and all this is done by the mind itself, without submitting to that minute experimental investigation which is necessary to establish the connections and relations of things. This was an error which deeply infected the syllogistic method of philosophizing: for the laws which regulate the human intellect being authoritatively laid down, whenever any new fact occurred it was instantly classified according to the prescribed forms; and the mind proceeded to pronounce concerning it, according to the rules which regulated its own operations, and not according to the positive facts which determined the nature of the thing. It is, however, a great mistake, to suppose, that our minds are the measures and criteria of the nature of things, since our perceptions are influenced by the capacities and circumstances of our own nature, rather than by a reference to the order of the universe.

2. Another general source of error, common to all mankind, arises from the pre-occupation of the mind by some favourite ideas. The mind being familiar with a few principles which it has found useful in solving some of the problems of nature, becomes so much attached to them that it applies them to the solution of every new appearance; and is not so anxious about examining specific differences, as in devising laws of analogy to connect new facts with notions already adopted: that these may remain inviolate, it either overlooks or undervalues, or explains away all the facts which contradict its previous conceptions.

3. The limited nature of the human faculties gives rise to another general source of error. The mind readily receives strong impressions from present objects; these, however, are frequently very incorrect; it is necessary to compare them with remote and heterogeneous examples, that the first vivid impressions may be modified or corrected, and that we may be enabled to form a fair and accurate conception of the phenomena which first arrested our attention. The mind, however, shrinks from the labour of such a process, and nothing but imperious necessity will ever make it submit to it.

4. Another general source of error arises from the restlessness of the human mind, which, in the investigation of causes, cannot rest satisfied with noting simple facts, but must get, as it were, behind the scenes, to see the mysterious, and, to vulgar eyes, invisible wires and springs by which cause and effect are connected. Failing, however, in this attempt, yet still anxious to explore the ultimate principles of things, the mind applies itself to the investigation of *final causes*, which are uniformly assigned according to the previous notions which men have imbibed, and not from any studied conformity to the general constitution of nature.

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* The language in which Bacon expresses these ideas can scarcely be translated, on account of its sententious brevity. His words are: Hujusmodi itaque sunt Idola, quæ vocamus Idola Tribus, quæ ortum habent aut ex æqualitate substantiæ spiritus humani; aut ex præoccupatione ejus; aut ab angustiis ejus; aut ab inquieto motu ejus; aut ab infusione affectuum; aut ab incompetentia sensuum; aut ab impressionis modo. *Nov. Org. Aph.* 52.

5. Another general source of error arises from the infectious influence of the passions. This has at all times a powerful effect, though it varies exceedingly with times and circumstances. Bacon specifies the following instances in which the affections influence the judgment. Our wishes prepossess the mind in favour of certain doctrines and opinions, *quod volumus facile credimus*. This operates universally in science, morals, and politics. Again, we are too impatient to encounter difficulties, and too ambitious to attend to things of a low and ordinary nature, from which we do not anticipate any splendid results. Superstition deters some from attempting to explore the *arcana* of nature; pride prevents others from submitting to the drudgery of experiment, and popular opinion makes others afraid to advance any that may appear paradoxical and uncommon. It is evident that many of the sources of error comprehended under this head have ceased to exist: but they operated powerfully in the infancy of philosophy; and their nonexistence, in modern times, shews the revolution which the general diffusion of knowledge has produced on the human mind.

All these errors, and many more which might be specified, belong to the *Idola Tribus*, or arise out of the constitution of the human mind, which, like a mirror of an uneven surface, distorts the images reflected from it.

But besides these general sources of error, every individual has an idol of his own, to which he bows in private, and which exercises an undue influence over his reason. These are the *Idola Specus*, and they enslave the mind, either in consequence of education or custom, or keeping certain company, or reading certain books, or respecting certain authorities, or from a thousand other accidental circumstances. One man is more fitted by his particular genius, or habits, for marking generalities; another for observing specific differences. These processes, when combined, are extremely useful, as they render the mind at once comprehensive and discriminating: but when separated, as they often are, the effect is always injurious; for attention to *minutiæ* cramps the intellect; the vast generalities of nature overwhelm it.

The *Idola Fori* arise out of the intercourse of society, and are of all others the most troublesome. For language is employed as the medium of intercourse; and words are formed, and names originally imposed, not on philosophical principles, but according to the comprehension and prejudices of the vulgar. All the efforts of philosophers have never been able to rectify the evil, and introduce into common use words of a precise and definite meaning. Every man, when he first begins to reason, takes words in their most ordinary acceptation: his mind is therefore prejudiced in the outset, and he will find it difficult to shake off the fetters, and attend to the nature of things apart from the ideas which their ordinary names impart. This evil is emphatically lamented by Bacon: *Unde fit ut magnæ et solennes disputationes hominum doctorum, sæpe in controversias circa verba et nomina desinant; a quibus (ex more mathematicorum) incipere consultius foret, easque per definitiones in ordines redigere. Quæ tamen definitiones in naturali bus et materiatis, huic malo mederi non possunt; quoniam et ipsæ definitiones ex verbis constant, et verba gignunt verba.* Aphor. 59.

The *Idola Theatri* are not natural and inherent, but assumed and adventitious; arising from the theories and hypotheses of philosophers, and from the currency which a great name never fails to give to some particular opinions. Such theories will always prevail; and Bacon thinks it only surprising that a great many more had not arisen in the times previous to his own. He hints, that it is probable that they will multiply with the freedom of discussion; and the present generation can bear testimony to the sagacity of this conjecture. Before his time the human intellect was confined within a narrow circle, and spent its force in harmless logomachies, without daring to touch the foundation of those systems, whether political or philosophical, which had been sanctioned by established usage. But, since his time, we have seen endless theories and experiments in education, in morals, in politics, in philosophy, and in religion. Men have not followed the judicious advice of Descartes, to hold fast even wrong opinions till they can be replaced by better; but the mind has been turned loose, without even the benefit of an erroneous chart, which, though faulty in its details, might nevertheless point its energies to some general aim. The maxim seems to have been, that every thing established was wrong, and that it was impossible to recede too far from it, in order to obtain the wished for improvement.

Such is a short commentary on the opinions of Bacon respecting the sources of error, which we trust will be found to be fairly deduced from the *novum organum*; which is certainly a wonderful work, whether we consider the time when it was written, or the comprehension of thought which it displays. To obviate these errors, he enforces the plan of rigid induction, and the dismission of all theories not founded on uncontroverted facts.

To these sources of error, we add the sophisms, or specimens of false reasoning mentioned by Aristotle, and other dialecticians. Bacon may be considered as furnishing weapons to attack the empire of nature, and Aristotle as supplying defensive armour to protect the assailant from injury in this arduous attempt.

1. The first fallacy in reasoning is styled *Ignoratio Elenchi*, or a mistake of the question. This is a common source of false reasoning: we every day see volumes written to establish a fact, which, when demonstrated, is nothing to the purpose; or does not invalidate the point to be disproved. A man, for instance, may attempt to prove that St. Paul was not a Jew by birth, from his own testimony, that he was born a Roman citizen: another may endeavour to shew, that he was neither a Jew nor a Roman, from the circumstance of his having been born at Tarsus, in Cilicia. All this arises from ignorance of the circumstances of the case, which, when rightly understood, will be found to imply no contradiction. We once witnessed an instance of this confusion of ideas in a court of justice. The judge thus questioned a witness. Did you hear A say that B had given him a blow which would be his death? The witness answered, No. Did you hear A say that B had *not* given him a blow? To this the witness also answered, No. The judge not perceiving that his evidence implied no contradiction, threatened to commit him to prison for perjury and equivocation. Whilst many are guilty of this sophism unconsciously, there are others who study it carefully, with a view to evade the conclusive arguments of their adversaries. The way to parry their sophistry is, to stick obstinately to the point in question, and never to notice an argument which does not bear upon it, unless it be to shew that it is nothing to the purpose.

2. Another species of sophism is called *Petitio principii*, or a taking for granted the thing to be proved. When a man has any favourite prejudice, it insensibly

infects his judgment; and, instead of submitting it to the fair decision of reason, it is assumed as a principle and criterion in reasoning. This is the origin of the *petitio principii*, when it slips insensibly into an argument, and in this it agrees with the errors of judgment stated by Bacon, as arising *ab infusione affectuum.* But this sophism is employed by every practised disputant as the means of confounding his antagonist; and great caution is necessary lest he introduce, under a disguised form, the point to be proved as one already admitted. When this is allowed, his victory is certain; and he cuts down his adversary with the weapons which he himself has furnished. It is easy to detect these fallacies in an author when plenty of time is allowed for consideration: but a disputant thinks slowness in reply an evidence of inferiority; and, therefore, often precipitately admits what leads to his own discomfiture.

3. *Reasoning in a circle*, is a sophism nearly akin to the *petitio principii*. It is practised, when, in a series of arguments, the same things are mutually made use of, both as the medium of proof, and as the conclusion.

4. *The non causa pro causa*, consists in assigning a false cause, or making that to be the cause of any effect, which either does not exist at all, or does not exist as a cause in the case in question. To this class belong all the theories not founded on facts, that have ever been formed respecting the constitution of mind and matter; such, for instance, as the Aristotelian method of explaining every thing by substantial forms; or the old pneumatological theory of ideas; or the modern one of vibrations; or any other that is assumed without a positive knowledge of the principles on which the reasoning is founded. This sophism, then, corresponds, in some respects, with the *Idola Theatri* of Bacon, who has, under that head, most forcibly illustrated its mischievous effects in science. It has also a deep influence on our moral reasonings, and frequently makes us state as a cause what is merely accidental and adventitious. On this principle, learning is sometimes decried as the cause of infidelity; and we have positively heard a bigot affirm that "Hell is paved with the skulls of the learned." On this principle, also, a savage who has recovered from a severe illness, after having drunk out of a certain well, considers that well ever afterwards as a specific for that complaint. Such is the origin of a thousand usages which still prevail, and which cannot be traced to any principle of reason. They have arisen out of superstition, or accident, or unwarranted inductions; and having obtained popularity, through the influence of the person who first introduced them, they often maintain, for centuries, an inveterate despotism over the rational faculties of man.

5. The *Fallacia accidentis*, is nearly allied to the former, and consists in drawing general conclusions from circumstances which are purely accidental. Of this kind is the memorandum of Smollett respecting a town in France. Having met at an inn with a scolding chamber-maid, and an awkward red-haired hostler, who had engrossed his whole attention, he immediately entered in his journal, "The men in this town are all red-haired, and the women all scolds." To gratify his spleen, he was guilty of a wilful sophism.

6. The sophism, *a dicto secundum quid, ad dictum simpliciter*, consists in deducing a universal assertion from that which is true only in particular circumstances. Similar to this would be the error of the grammarian, who should explode a general rule for the sake of a simple exception; or who should raise the exception to the dignity of a rule. The common maxim, *exceptio firmat regulam*, is logically true, and may help to the detection and solution of this sophism; for an exception never could be discovered without the previous recognition of a general rule.

This sophism has its reverse, as when we apply a general truth to all particular circumstances. Thus, from the general maxim that it is wrong to infringe the rights of another, it might be argued that it is improper to withhold his sword from a madman, or to abridge his liberty. This is the way in which madmen and children usually argue; and it is the way in which most men will argue when their private rights are sacrificed to public expediency. If individuals would reflect that they are not entitled to any right inconsistent with the general interests of society, it would rectify their reasoning, and might perhaps compel the submission of their judgment, even in opposition to their feelings.

7. The sophism of composition consists in affirming any thing in a compound sense, which is true only in a divided sense. The sophism of division is the reverse of this.

8. The last sort of sophisms arise from the ambiguity of words. This forms a most extensive class of sophisms, and many of the others may be reduced to it.

Having thus stated the principles of false reasoning, and pointed out the means of detection, we shall now afford our readers an opportunity of trying their ingenuity in solving some of the most celebrated of the logical quibbles, or Eristic syllogisms of the ancients. We would not, however, have them die of vexation, should they not be able to solve them, as we are told some of the ancient sophists did. But it may be useful to them to see how ingenious the mind can be in puzzling itself with its own undefined conceptions.

1. The sophism called *The Lying*, from the example, was this. "If, when you speak the truth, you say you lie, you lie; but you say you lie when you speak the truth; therefore, in speaking the truth, you lie." This appeared such a mighty puzzle, and so very important, that Chrysippus wrote six books upon it; and Philetas, a Choan, died of a consumption, which he contracted by the close study which he bestowed upon it. As the reward of his labour, his tomb was inscribed with the title 'Ο ψευδομενος.

2. *Electra.* "Electra, the daughter of Agamemnon, knew her brother, and did not know him; she knew Orestes to be her brother, but she did not know that person to be her brother who was conversing with her."

3. *Sorites.* "Is one grain a heap? No.—Two grains? No.—Three grains? No.—Go on adding one by one; and if one grain be not a heap, it will be impossible to say what number of grains make a heap."

4. *The Horned.* "You have what you have not lost; you have not lost horns; therefore you have horns."

5. To these may be added the argument against motion, invented by Diodorus of Caria. "If any body be moved, it is either moved in the place where it is, or in a place where it is not: but it is not moved in the place where it is; for where it is, it remains: nor is it moved in a place where it is not; for nothing can either act or suffer where it is not: therefore there is no such thing as motion." This philosopher met with a practical application of his own argument, which proved rather an unfortunate *argumentum ad hominem*. Having had the misfortune to dislocate his shoulder, the surgeon whom

he sent for endeavoured to convince him that it could not be a dislocation, as it was impossible, on his own principles, that the bone could have moved out of its place." Enfield's *History of Philosophy*, vol. i.

6. Zeno's paradox respecting motion, to which he gave the name of *Achilles*. By this he endeavours to prove that Achilles could never overtake a tortoise, though the slowest of animals. "The tortoise is a mile before Achilles at starting, and Achilles runs a hundred times faster than the tortoise, yet he will never overtake it; because, when Achilles has run one mile, the tortoise has moved forward the hundredth part of a mile. Again, whilst Achilles passes over this hundredth part of a mile, the tortoise has moved on the ten-thousandth part of a mile, so that it is not yet overtaken. In the same manner, whilst Achilles runs over that ten-thousandth part of a mile, the tortoise has moved on the millionth part of a mile, and is not yet overtaken; and so on, *ad infinitum*." It would not be easy to solve this quibble, were we to measure motion merely by *space*, without taking in the idea of *time*.

We close these specimens of egregious trifling with the report of a law-suit, conducted on the principles of the Eristic philosophers. Protagoras, the sophist, had agreed to instruct a young man in eloquence for a large sum, one half of which was to be paid in hand, and the other half as soon as he should gain a plea in the courts. The pupil, however, made no attempt to plead for a long time after he had been fully instructed in the principles of rhetoric. The sophist therefore brought an action against him to recover the remaining half of the stipulated sum. Each pleaded his own cause. Protagoras urged, that whatever way the decision of the judges should lie, his pupil would be bound to pay; for if they should find him liable, he must pay in conformity with their sentence; or if they should acquit him, then, in that case, he must pay in conformity with their original agreement, which was, that the full sum should be paid on his gaining a cause. The young man, on the other hand, pleaded, that if the cause was decided in his favour, he should be excused from payment by the decision of the court; if against him, Protagoras, by his own agreement, could have no demand upon him, as he was only bound to pay on gaining a cause. If our readers find any difficulty in solving this knotty question, they may leave it, as we are told the judges did, undecided.

Such has been the revolution of philosophical opition, that syllogism, which, for so many centuries, had been considered as the grand bulwark of reasoning, is now almost universally exploded; and any man who should digest his arguments into a syllogistic form, or who should say a word in favour of the practice, would excite ridicule rather than produce conviction. The authority of Bacon, of Locke, of Reid, and of Stewart, (not to mention hundreds of their followers, who, under their protecting shield, have furiously attacked a doctrine which they never attempted to comprehend,) would of itself have been sufficient to shake the credit of a system to which the philosophical world had so long bowed with submission. The objections against syllogism, as a method of investigating truth, are forcibly stated in the following aphorism of Bacon: *Syllogismus ex propositionibus constat, propositiones ex verbis, verba notionum tesseræ sunt. Itaque si notiones ipsæ, (id quod basis rei est,) confusæ sint, et temere a rebus abstractæ; nihil, in iis quæ superstruuntur, est firmitudinis. Itaque spes est una in inductione vera.* This is undoubtedly true; yet we are not to suppose that first principles were neglected in the Aristotelian philosophy. On the contrary, it professedly begins with the consideration of simple terms; but, instead of directing its principles to an accurate examination of facts, and to the right application of appropriate and well-defined terms, it proceeded to arrange the simple terms which represent things under the ten categories, which are so many mental abstractions, and which have a tendency to confine the mind to the contemplation of its own resources, instead of teaching it to correct its conceptions by examining the properties of things.

Syllogism, however, may be useful in detecting false reasoning, though it does not naturally lead to the discovery of any new truth. In this view of it, syllogism may be called the grammar of reasoning; and as the object of grammar is not to invent language, but to arrange it, so syllogism merely details the processes which the mind unconsciously employs in the arrangement of a legitimate argument. Forcible and energetic language does not arise from studying the rules of grammar, but from vivid conceptions, accurately represented by some of the methods which we have already described as lying at the foundation of language; and clear reasoning can only proceed from accurate perceptions of the distinctions or affinities of things, by which things incongruous are separated, and things similar or analogous are conjoined. Syllogism cannot aid invention any more than a knowledge of the figures employed in rhetoric can make an accomplished orator. At the same time, it would be absurd to affirm that reasoning and eloquence cannot be improved by a proper system of education. The object of education is not to evolve new faculties either of body or of mind, but to improve those which are natural. Though a man can walk, and run, and leap, yet still,

> ——"Those move easiest who have learned to dance."

Though every man is taught by nature to use his arms as instruments of defence, yet the trained pugilist will always have a decided advantage over the untutored rustic; though every man can speak, yet a grammatical education will enable him to speak not only with greater accuracy, but with greater ease and elegance than he ever could have attained without such training; and surely, though every man is furnished by nature with the elements of reasoning, yet care and attention will greatly improve the faculty, and make it at once more inventive and more discriminating. The only question then, is, Whether the Aristotelian method of Syllogism be the best adapted for this purpose; and here we think it ought to be regarded rather as furnishing an inventory of the furniture of the human mind, than as pointing out the way in which its acquisitions may be enlarged. It is impossible, however, not to admire the acuteness of mind displayed by the inventor of this art; and we are happy to agree with Mr. Stewart, who, after exposing the extravagant pretensions of syllogism, recommends an attention to it as essential to a liberal education.—Let the student, then, who ardently aspires to the investigation of truth, apply his first attention to facts, experiments, and observations, as lying at the foundation of human knowledge;* but let him not despise syllogism as a means of detecting false reasoning. Human knowledge is not more promoted by establishing right principles than by deducing from them sound inferences. The latter is properly the province of syllogism; and certainly an accurate attention to the principles of reasoning, and especially a constant vigilance against the errors and prejudices which warp the judgment, must always be useful in leading to sound and accurate conclusions. Syllogism may be called the *fencing* of the understanding; and as a puny antagonist, however dexterous in the use of his weapons, will never prevail over great natural strength and courage, so syllogism will never enable a weak understanding to triumph in argument: but, *cæteris paribus*, it gives an advantage, both by enabling the disputant to methodise his own arguments, and to analyse more readily the arguments of his opponent.

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* *Syllogismus ad principia scientiarum non adhibetur.*—Nov. Org. Aph. 13.

The following short abstract, taken chiefly from Enfield's *History of Philosophy*, will be sufficient to give a general idea of the doctrine of syllogism. Every proposition consists of a subject, a predicate, and a copula; or expresses the thing concerning which an assertion is made, the accident which is predicated of it; and the assertion itself. A syllogism consists of three propositions, of which the two former are the premises, and the third the conclusion. These three terms are called the major, the minor, and the middle term. The predicate of the conclusion is called the major term, the subject the minor, and both together the extremes. The middle term is that which is introduced to show the connection between the major and minor, and thus bring out the conclusion. These positions are illustrated by the following examples. *God is omnipotent* is a proposition: in which *God* is the subject, *omnipotent* the predicate, and *is* the copula.

> Our Creator must be worshipped;
> God is our Creator;
> Therefore God must be worshipped;

is a syllogism in which the two former propositions are the premises, the third the conclusion. The three terms are *Worship*, *God*, *Creator*; the first the major, the second the minor, the third the middle term, introduced to show the connection between the two ideas of *God* and *worship*.

The matter of a syllogism is the propositions of which it consists. The form is the framing and disposing of these according to figure and mode. Figure is the proper disposition of the middle term. Mode is the arrangement of propositions according to quantity and quality; that is, as they are universal or particular, affirmative or negative.

The figures of syllogisms are three: in the first the middle term is the subject of the major proposition, and the predicate of the minor.

> Every bad man is miserable;
> All tyrants are bad men;
> Therefore all tyrants are miserable.

In the second figure, the middle term is the predicate of both the extremes.

> No deceiver is to be credited;
> Every good historian is to be credited;
> Therefore no good historian is a deceiver.

In the third figure, the middle term is the subject of both the extremes.

> All honest men are beloved;
> All honest men have faults;
> Therefore some who have faults are beloved.

We do not reckon it necessary to prosecute this subject farther, as our object is not to exhaust, but to excite discussion. Under the first head of this article we have endeavoured to give an independent view of the manner in which the mind obtains its knowledge and employs its resources. In doing this, we have been influenced by no predilections in favour of any particular system, but have stated the reflections which result from our own experience and observation. Under the second head, little remained for us to do but to give a commentary of our own on what has been already written; and in this also we have kept in view the same independence of thinking, respecting the talents of those who have laboured successfully in the same field, but perfectly satisfied that the ground is not yet so completely preoccupied by any, as to cut off the hopes of earning well-deserved honours in the science of pneumatology.

In addition to what we said in the outset, respecting the importance of the science to which we have ventured to offer our humble contributions, we have only to observe, in conclusion, that nothing tends so much to enlarge the mind, and sharpen the intellect, as to contemplate the sources of our pleasures and our knowledge; to mark the steps by which certain tastes and feelings have been generated, and thus to ascertain the accuracy of our conceptions, and their correspondence with their exciting causes, whether existing in the external world, or in the nature of the mind itself. If this is not genuine knowledge, we scarcely know what deserves the name. Such researches as these constitute the substance of rational logic, which explains not only the source of our intellectual ideas, but shews also the origin of our moral perceptions.

Logic, in its metaphysical aspect, may appear a little repulsive; but it is most attractive, when considered as the handmaid and expositor of that useful knowledge which is connected with the business and enjoyments of life. Whatever, then, may be the efficacy of the prescribed rules employed for the purpose of stimulating or strengthening our intellectual faculties, there can be no doubt that the man who attends to the operations of his own mind, and marks the processes by which his tastes and opinions have been produced, will be the best qualified to reason with fairness, precision, and acuteness: and, farther still, we have little hesitation in subscribing to Mr. Harris' assertion, that "every thing really elegant or sublime in composition is ultimately referable to the principles of a sound logic."

We have been accustomed to hear the praises of the mathematical studies, as contributing to the strength of the reasoning faculties. The ουδεις αγεομετρητος εισιτω of Plato has been echoed from his day to this, and it has become fashionable with many to maintain, that no man can reason accurately who is not a geometrician. We have always entertained very opposite sentiments; and are ready to contend that mathematics are applicable only to mathematical subjects; and that they are not only of no use in moral reasoning and logical deductions, but are positively unfriendly to them. The subjects treated of are totally different; the mode of investigation, and the end aimed at in morals and in mathematics are also different; so that it seems impossible to establish any alliance between them, or to make the one auxiliary to the other. The man would be deservedly laughed at, who should attempt to establish a moral truth by mathematical arguments; and he will not succeed much better who applies the language of passion and figure to mathematical and physical researches. Mathematics admit of rigid demonstration; moral reasoning does not; yet it admits of certainty: we cannot demonstrate that the sun will rise to-morrow, but the man would be reckoned insane who should seriously doubt of it. We cannot positively demonstrate what will be the consequence of any particular system of polity, yet we confidently infer the future from the past; and human life is regulated by probabilities, founded on the general principles of our nature, which, though they may appear considerably diversified by accidental circumstances, can never recede very far from the rule established by the constitution of our minds, and by the order of nature.

Moral and metaphysical discussions are much more difficult and complicated than those which are purely mathematical; and yet the latter are captivating from their variety and their applicability to all the phenomena of the material world. We need not, therefore, be surprised that the mathematical sciences, so varied in their application, and susceptible of such rigid demonstration should fix some minds which could not be attracted by any beauties of taste, or any charms of moral discussion; but we should have some reason to be surprised, if, after being devoted to these fascinating pursuits, they should ever attend with pleasure or with profit to any thing else.

In morals, absolute truth is not always attainable; for though truth, in its own nature, is immutable, and its power recognized in every human breast, yet the prejudices over which it asserts its empire yield a reluctant obedience, and, in too many instances, obscure its dignity and weaken its power. In short, our feelings are so mixed up with all our moral reasonings, that they too frequently give a distortion to the truth, and render it repulsive to those whose minds are influenced by different associations and prejudices.

To search for truth under these circumstances, though perhaps discouraging to those who have been accustomed to the infallible certainty of mathematical demonstration, is nevertheless interesting, not merely as an object of study, but as absolutely necessary for the knowledge and right management of human nature, and for our own improvement as moral and social beings. A mere mathematician is apt to consider both morals and religion, in which there exists such an immense variety of opinions, as things altogether conventional and uncertain; whilst a man who is versant in the knowledge of human nature, and acquainted with the circumstances which tend to give a wrong bias to the judgment, will learn to distinguish truth from the prejudices by which it is too frequently obscured; and whilst he makes every reasonable allowance for involuntary error, he will see the necessity of guarding vigilantly against those mistakes, which exert an unfriendly influence on his happiness and hopes as a rational and immortal being. The knowledge of human nature would present no variety, and convey no useful lessons, did truth appear exactly in the same light to all; for there would be then a perfect identity of thinking and feeling. Morals and politics would be expunged from the number of the sciences, and would take their place with the incontrovertible instincts of our nature.

But though truth be worshipped, to use a mythological figure, under different forms, and sometimes even with opposite rites, she has, nevertheless, generally speaking, the same attributes assigned to her, and her identity may be recognized, though disfigured under fantastic or absurd appearances. The search after her is always delightful; and we are fully recompensed for our trouble, even though we should only gain a glimpse of the beauties which strew the road that leads to her temple. (*g*)

LOGWOOD. See Dyeing.

LOHEIA, a town of Yemen in Arabia, is situated in 15° 42′ 8″ north latitude, and 42° 18′ 45″ east longitude, and built on the south-west side of a peninsula, which is surrounded by the sea on every side, except the east. The bay before the town is very shallow, which prevents vessels from approaching close to the place; and in the middle of the neck of the peninsula is a small mountain, which serves as a fortress, with two towers provided with cannon, and reaching across on each side of the hill to the shore. The houses are constructed of mud, and thatched with dried grass. The soil around the town is a black alluvial earth, strongly impregnated with salt, and sending forth so powerful an effluvia, as to occasion a prickling sensation in the legs of strangers. Fish, butcher meat, and all kinds of provision, are plentiful and reasonable, and a good supply of fruit, chiefly grapes and bananas, is brought from the mountains by the Bedouins. Those people who reside in the skirts of the town, supply it also with milk and firewood; but the water, which is brought in skins upon camels from the adjoining mountains, and which is merely the rain water collected in the sand, is of a bad quality. The thermometer, during the visit of Mr. Bruce to Loheia, was 81° at its lowest, on the 9th of August, wind south by east, and 99° at its highest, on the 30th of July, wind north-east. The barometer, during the same space, was observed from 26° to 26° 9′.

The articles of commerce in Loheia are of the same description as those of the other ports in the Red Sea. The customs, at the time of Mr. Bruce's visit, were 5 per cent. upon goods directly from India, (though at Mocha the rate was only 3 per cent.) and 7 per cent. upon all goods whatever brought by merchants from Jidda. The inhabitants, having been accustomed to trade, are of gentle manners; and the women show great attention to their dress and persons. They are more corpulent than the men, and many of them are of a fair complexion. There are many Abyssinian slave girls who are preferred as wives by the Loheians, as they continue to bear children for a longer period than the Arab women. See Bruce's *Travels*, vol. ii. 8vo. ed. (*q*)

LOIR, and Cher, one of the central departments of France, derives its name from that of the two rivers by which it is traversed. It is formed out of the old provinces of Blaisois and Vermandois. It is bounded on the north by the departments of the Eure and Loire; on the west by those of the Sarthe, and the Indre and Loire; on the south by that of the Indre; and on the east by that of the Cher. The principal rivers which water the department are the Loire, the Loir, the Beuvron, which passes by Bracieux, and the Saudre, which rises near Salbris. The department is 34 leagues long, and 23 broad, and contains 6717 kilometers, or 340 square leagues. It is divided into three districts. That of Romorantin comprehends all the ancient Sologne. It is 118 square leagues in extent, but is covered with heaths and marshes. It produces, however, some rye, barley, and oats. The district of Blois, which is the largest, is fertile in grain, wines, and pasturage; and that of Vendome, the smallest of the three, has the same productions as Blois. The following are its principal towns:

	Inhabitants.
Blois,	13,312
Vendome,	7,555
Romorantin,	5,730

Blois is the capital of the department. The contributions in the year 1802 were 2,432,733 francs. The forests occupy 144,000 acres. Population 211,152.

LOIRE, is the name of one of the eastern departments of France, and derives its name from the river Loire, which traverses it. It is formed out of the old provinces of Beaujolois and Forez; and is bounded on the north by the departments of the Saone and Loire, and that of the Allier; on the west by the same, and by that of the Puy de Dome; on the south by that of the Upper Loire and the Ardeche; and on the east by those of the Isere and the Rhone. The principal rivers are the Loire, the Gers, the Vecise, and the Furens. It is 24 leagues long, and 12 broad, and contains 260 square leagues. This department produces grain, wine, hemp, coal, iron, and mineral waters. The following are its principal towns:

	Inhabitants.
Montbrison,	4,703
St. Etienne,	16,259
Roanne,	6,992

Montbrison is the capital of the department. The contributions in the year 1802 were 2,843,809 francs. The forests occupy about 92,000 acres. Population 292,308.

LOIRE, Upper, is the name of one of the south-east departments of France, which derives its name from its position near the source of the Loire. It is formed out of the ancient Velai; and is bounded on the north by the departments of the Loire and the Puy de Dome; on the west by that of the Cantal; on the south by those of the Lozere and the Ardeche; and on the east by the same, and by that of the Loire. It is watered by the Loire, the Allier, and the Borne. It is 26 leagues long, and 17 broad, and contains 267 square leagues. The department is covered with snow for more than six months in the year. The principal productions are grains, wines, excellent pasturage, cattle, horses, oxen, mules, and lead. The cattle, butter, and cheese, form the principal articles of commerce in the districts of Brioude and Issengeaux. The following are the chief towns:

	Inhabitants.
Puy,	15,915
Brioude,	5,386
Issengeaux,	5,261

Puy is the capital of the department. The contributions in the year 1802 were 1,509,642 francs. The forests occupy about 45,000 acres, and the population is 237,901.

LOIRE, Lower, is one of the western departments of France, and derives its name from its position near the embouchure of the Loire. It is formed out of the bishopric of Nantes, and is bounded on the north by the departments of the Ille and Vilaine; on the west by that of the Morbihan, and by the sea; on the south by that of La Vendée; and on the east by that of the Maine and Loire. It is watered by the Loire, the Vilaine, and the Sevre Nantaise. It is 30 leagues long, and 27 broad, and has a superficial extent of 788 square leagues. It produces grain, hemp, wool, cattle, marbles, salt, and fish of all kinds. In the district of Paimbœuf, the salt-works are numerous. The district of Ancenis contains coals, and that of Chateaubriant is entirely covered with wood. The following are the chief towns

	Inhabitants.
Nantes	73,879
Paimbœuf	4,220
Chateaubriant	3,049
Ancenis	2,923
Savenay	1,814

Nantes is the capital of the department: the contribution, in the year 1802, was 2,900,662 francs. The forests occupy about 78,000 acres. Population 368,500.

LOIRET, one of the central departments of France, derives its name from the river Loiret, by which it is watered. It is formed out of the old provinces of the Orleanois and the Gatinois; and is bounded on the north by the department of the Seine and Marne, and the Seine and Oise; on the west by those of the Eure and Loire, and the Loire and Cher; on the south by those of the Loire and Cher, and the Cher; and on the east by those of the Nievre and the Yonne. The chief rivers are, the Loire, the Loing, and the Loiret. The productions of the department are, grains, wines, vinegar, saffron, brandy, butter, and wool. The district of Orleans produces excellent wines, and Pithivien is famous for its game. The department is 30 leagues by 924 broad, and contains 357 square acres. The chief towns are—

	Inhabitants.
Orleans	36,165
Montargis	6,394
Gien	5,117
Pithiviers	3,071

Orleans is the capital of the department. The contributions in 1802 were 3,778,705 francs. The forests occupy 181,000 acres. Population, 289,728.

LOLOS. See China.

LOMBARDS. See Italy.

LOMBARDY. See Italy.

LOMOND, Loch. See Dumbartonshire.

LOMOND, Ben. See Dumbartonshire.

LONDON.

The city of London, the capital of the British empire, and the most populous city in Europe, if not in the whole world, is situated in England. Taking the word in its most usual and extended application, London may be described as situated on both banks of the river Thames. By far the largest portion of it, and which includes that which, strictly speaking, is called London, lies on the northern banks of the Thames, in the county of Middlesex, and hundred of Ossulston. The smaller portion, on the south banks of the Thames, lies in the county of Surry, and hundred of Brixton, with the exception of the parishes of Deptford and Greenwich, (if they may be regarded as part of the metropolis,) which lie in the county of Kent, in Sutton Lathe. The latitude of St. Paul's Cathedral, in London, is 51° 31′ north; and its longitude 0° 5¾′ west from Greenwich.

London is admirably situated for commerce and salubrity. The great part of the northern division stretches along the banks of the Thames, and rises from thence with a gradual ascent, towards the hills of Hampstead and Highgate; and though that part which lies in Surry is on level ground, which was formerly either the bed of the river or a morass, yet, by the embankments of the Thames, and the numerous sewers and drains, it is equally healthy, though not so pleasant an abode as the northern division of the metropolis. The soil near the river on both sides is a gravel; but on the north side, as the ground rises, this gravel is covered with brick earth, or a strong loam, to the depth of several feet.

By far the greatest extent of London is from west to east. Even without including Knightsbridge, Kensington, or Chelsea, its length from Hyde Park corner to Poplar is nearly seven miles; its breadth, at the narrowest part, does not exceed two miles; in other parts, it nearly reaches four miles. The walls of the ancient city included an area one mile and a half long from east to west, and rather more than half a mile in breadth from north to south. The area of all the parishes now included in London, in the most usual and extended acceptation of the word, comprises about 30 square statute miles, or 19,200 statute acres.

London is divided into the city of London within the walls; the city of London without the walls; the city and liberties of Westminster; the out-parishes in Middlesex and Surry; and the parishes not included in the bills of mortality. The parishes in what are called the bills of mortality amount to 146, viz. 97 within the walls, 16 without the walls, 23 out-parishes in Middlesex and Surry, and 10 in the city and liberties of Westminster. The parishes not included in the bills of mortality are, Chelsea, Kensington, St. Mary-le-Bone, Paddington, and St. Pancras, with part of Highgate. The appellation of out-parishes is taken from the London bills of mortality, which were first used in the year 1562, and from 1603 are regular. These bills were intended to afford notice of the increase of the plague. The city of London, without the walls, is an extension of the old city, and under the same jurisdiction. The principal parishes and places comprehended in the town out-parishes are in Surry, the borough of Southwark, which contains six parishes, and is divided into two parts, called the Borough Liberty, and the Clink; Lambeth, South Lambeth, Vauxhall, Newington Butts; Berbmondsey, Horsleydown, and Rotherhithe: in Middlesex, St. Andrew's, Holborn and liberties; St Giles, St. George's, Bloomsbury, part of Pancras, Clerkenwell, Spitalfields, and Bethnal Green, St. Luke's, Shoreditch, Whitechapel, St. George's on the east, Shadwell, Limehouse, Islington, Hackney, Stepney, and Strafford-le-Bow. St. Mary-le-Bone, which is without the bills of mortality, is one of the largest parishes in London, its population amounting to nearly 80,000. In consequence of the great increase of population of some of the out-parishes, they have been subdivided. This has been particularly the case with the parish of Stepney. It formerly included those of Stratford-le-Bow, Whitechapel, Limehouse, Wapping, Shadwell, Ratcliffe-Highway, Spitalfields, and Bethnal Green; and even now is one of the largest in the bills of mortality. The city of Westminster, which is now considered as forming part of the metropolis, though governed by a separate jurisdiction, was for many centuries entirely distinct from London; and a road leading from the village of Charing, where Edward III. erected a cross in memory of his Queen Eleanor, ran thence to the city, which still retains its ancient appellation of the Strand. The city of Westminster is bounded on the east by Temple-Bar, the only one of the city gates now standing, and a line leading nearly north from that place till it meets the parishes of St. Giles and St. Andrew's, Holborn; on the west it stretches as far as the parishes of Chelsea and Kensington; on the south it is bounded by the Thames; and on the north-west it comprises the south side of Oxford Street.

It has been remarked, "that it is much easier to acquire a practical knowledge of the geography of London than of Paris, which has not the same rallying points, except the Seine." In London, the principal streets follow the course of the Thames from west to east, and the main cross streets run chiefly in a direction from north to south. Entering London from the west, there are two principal avenues, or grand lines of streets: If we enter from the west, on the northern side of the city, the first street is Oxford Street, which leads through St. Giles, Holborn, Skinner Street, Snow Hill, Newgate Street, Cheapside, Cornhill, and Leadenhall Street, to Whitechapel and Mile-end on the road into Essex: If we enter by the Bath road, on the south side of Hyde Park, the streets are Piccadilly, St. James' Street, Pall Mall, Charing Cross, Strand, Fleet Street, Ludgatehill, St. Paul's Church-yard, Watling Street, Cannon Street, Tower Street, Wapping, Limehouse, &c. The two principal avenues, Piccadilly and the Strand, Oxford Street, and Holborn, unite at St. Paul's; whence, as from a common centre, they separate again, to form two other great avenues, Cheapside and Watling Street. "They are the arteries of this great body, and all the other streets are the veins, branching out in all directions." The longest line of street, though under several different names, which runs from south to north, is the principal street in Southwark, which extends from the country to London Bridge; and thence, under the names of Fish Street Hill, Gracechurch Street, Bishopsgate Street, Shoreditch, &c. to the northern extremity of the city, on the road to Kingsland, Hackney, &c. The longest street in London under one appellation, is Oxford Street, which is 1 mile, 2 furlongs, and 19 poles in length. The only other streets which extend above a mile, are Grays-Inn Lane, which is 1 mile and 24 poles; and Thames Street, upper and lower, which is 1 mile, 1 furlong, and 2 poles. The streets near the Thames, and most of the cross streets, are extremely narrow: The broadest and handsomest are to the north of Oxford Street, especially on the north-west corner of the metropolis. With the exception of a very few unfrequented streets on the south of the river, they are all extremely well paved, and on each side are flag stones for the convenience of foot passengers. "Underneath the pavements are large vaulted channels, called sewers, which communicate with each house by smaller ones, and with every street by convenient openings and gratings, to carry off all filth that can be conveyed in that manner into the river. The mud and rubbish on the surface is regularly and carefully removed whenever it is necessary. A great part of London is lighted with gas. In the beginning of 1817, the total consumption of coals daily in London, for the purpose of illumination, amounted to 28 chalders; and the number of lights supplied, to 76,500. At present, (Nov. 1818,) as the north-west of London is lighted, the consumption of coal must be much greater, and the lights more numerous. In case of fire, there are fire-cocks, connected with the water-pipes at short distances, in every street.

It is calculated that London contains about 8000 streets, lanes, alleys, courts, &c. 60 squares, and 160,000 houses, warehouses, and other buildings. The plan of most of the houses is very simple; two rooms in each storey, with three or four stories above ground, and one under the level of the streets. Each storey has a large room in front, with two or three windows looking on the street; the other room looks on a yard behind, which is generally very small. The stairs are generally taken out of the breadth of the back room. The ground floor is usually elevated a few feet above the level of the street, from which it is divided by an area, generally from three to eight feet wide, and six or eight feet deep, enclosed by an iron railing. The windows of the kitchen, which is in this sunk storey, are in this area. A bridge of stone or brick leads to the door of the house. The front is about twenty or twenty-five feet wide. The houses of London, of all descriptions and sizes, (with very few exceptions,) are built of brick, of a pale colour, evidently containing a large proportion of sand in their composition. The description just given applies only to the general class of houses. Those inhabited by the rich merchants, gentry, and nobility, contain a very great number of rooms, some of them often of a very large size, and are constructed, both externally and internally, with all possible regard to convenience, luxury, taste, show, and magnificence. The highest rented houses, such as those in Hamilton Place, Piccadilly, Grosvenor Square, Portman Square, Portland Place, &c. let for about 1000*l.* a-year; but there are few of this class of houses to be let, being principally occupied by the proprietors. The second class of houses let for from 400*l.* to 800*l.* a-year; and the rents vary according to the size, convenience, and situation, from 40*l.* to 200*l.* a-year. Houses with shops belonging to them, in the best streets for retail business, such as Cheapside, Cornhill, Holborn, Oxford Street, Piccadilly, Pall Mall, St. James' Street, Bond Street, &c. let from 150*l.* to 300*l.* a-year. The largest and most magnificent houses belonging to the nobility, are Apsley House, Devonshire House, and Burlington House, in Piccadilly; the houses of the Marquis of Stafford and Earl Spencer, that look into the Green Park; York House, in the Stable Yard, St. James's; Marlborough House, in Pall Mall; Northumberland House, Charing Cross; the Marquis of Lansdown's, Berkley Square; Chesterfield House, Mayfair; and Uxbridge House, Burlington Gardens.

The most numerous assemblage of large and elegant houses are to be found in the squares. Of these, Grosvenor Square is generally deemed the finest and most fashionable; it contains five acres—is beautifully laid out with evergreens—and adorned with an equestrian statue of George II. The other principal squares are, Portman Square, Berkley Square, St. James' Square, Hanover Square, Manchester Square, Cavendish Square, Bedford Square, Montague Square, Bryanston Square, Russel Square, Bloomsbury Square, &c. In Portman Square there are many very large and excellent houses. Berkley Square lies on a slope; which circumstance, united to the shrubbery in the middle, and the fine grounds about the Marquis of Lansdown's house, which is situated at the bottom of it, gives it a more picturesque appearance than any of the other squares in London. St. James' Square has a dull and uninteresting appearance, partly from the want of a shrubbery in the centre, and partly from the buildings not being uniform; there are, however, many excellent houses in it, particularly Norfolk House. Manchester Square is small, but very neat: The house on the northern side, generally inhabited by the Spanish ambassador, is one of the best in London. Russel Square rivals Grosvenor Square in point of magnitude, though not in the size and magnificence of its houses. Being one of the modern built squares, care has been taken to ventilate it more thoroughly than the older built squares, by the broad streets which intersect it at the corners and the middle. On the south side, where the Bedford House formerly stood, is a beautiful statue of the late Duke of Bedford. The most magnificent of all the squares in point of size, and, if the gardens are taken into consideration in conjunction with it, certainly the most beautiful, is Lincoln's-Inn-Fields. It is said to be equal to the base of the largest of the pyramids of Egypt. Besides the squares, there are several other regular masses of buildings deserving of notice, particularly Waterloo Place, at the foot of the new street which is to run from Carlton House to the Regent Park; and the three circuses that are to adorn this street, where it crosses Piccadilly and Oxford Street, and at the top of Portland Place. With the exception of the palaces, we shall defer our account of the other public buildings in London, till we come to the consideration of the particular purposes for which they were erected.

St. James' palace was anciently an hospital for lepers. In 1532 it was surrendered to Henry VIII. who built the present palace, and enclosed St. James' Park. The court, however, was not held here till the time of Queen Anne: and since the king's illness it has been removed to Buckingham House. St. James' palace is a very mean building, situated very low. About nine years ago, the south-eastern wing was destroyed by fire, and it is still in ruins. The state apartments, however, are still uninjured. Some of the other apartments are occupied by the Duke of Clarence and the Duke of Cumberland: the rest are inhabited by the king's servants.

At the west end of St. James' Park is Buckingham House, or the Queen's palace. It was built by the Duke of Buckingham in 1703, bought by the nation in 1761, and settled on the Queen in 1775. Its appearance is handsome rather than magnificent. It is built of red brick. Many of the apartments are richly furnished, and contain some valuable pictures. Behind the house are extensive and pleasant gardens. Carlton House, the town residence of the Prince of Wales, is situated at the east end of Pall Mall. Its situation is bad, and its general appearance by no means grand. The screen, however, with its colonnade, which divides it from Pall Mall, is beautiful. The rooms are small and inconvenient. The furniture is uncommonly rich and splendid. Besides other curiosities, it contains a very extensive armory. The gardens, which lie between it and St. James' Park, are laid out with considerable taste. Whitehall palace occupies only a very small part of the site of the old palace, which stretched along the banks of the river, from Privy Gardens to Scotland Yard, and from the river to St. James' Park, including the area, on which are now built the houses of the Earl of Liverpool, the Duke of Buccleugh, &c. and the Horse Guards, Treasury, and Admiralty. The present palace is more generally called the Banqueting House, the great room of which is used as a chapel. The cieling was painted by Rubens; and in the court behind the banqueting house, is a very fine brass statue of James II. by Gibbons. Kensington palace was the favourite residence of King William III. Queen Anne, and George II. It is of considerable extent, built of brick, but by no means magnificent, handsome, or even regular. It is particularly distinguished for its finely painted staircases and cieling; and for several rare and valuable pictures by Holbein, Albert Durer, and other distinguished masters. The Dukes of Kent and Sussex, and the Princess of Wales, have apartments in this palace.

The large portion of the metropolis which lies on the south bank of the river, as well as the constant intercourse which must have subsisted for many centuries between the southern and south-eastern counties of England and its capital, must, one would have thought, have rendered several bridges over the Thames indispensably necessary; and yet, till the middle of the 18th century, there was only one, viz. London Bridge. This was begun to be built of stone (the wooden bridge having been burnt) in the year 1176, and was finished in 1209, the course of the river being for the time turned another way, by a trench dug for that purpose, beginning, it is generally believed, east near Rotherhithe, and ending in the west near Battersea. Till the middle of the last century, it was very inconvenient, from the houses with which it was crowded, the consequent narrowness of the passage for carts, &c. and the smallness of the arches. Even yet it is very inconvenient, dangerous, and ugly. Every arch is of a different size, and there are more solid than open parts. "It is in fact like a thick wall, pierced with small unequal holes here and there, through which the current, dammed up by this clumsy fabric, rushes with great velocity, and, in fact, takes a leap, the difference between high and low water being upwards of 15 feet." The fall, of course, at about half ebb tide, is very great, and the passage at that time dangerous, except to experienced and careful watermen. The small boats generally take the third arch from the Middlesex side; but the barges pass through the centre and largest arch. There are few sights in London so strikingly grand, as that of a large west country barge passing under this arch at the time of the greatest fall The bridge is 915 feet long, and 45 broad. There are 19 arches, none of which, except the centre arch, are more than 20 feet wide; some of them are only 8 feet; the centre arch, which was formed by throwing two into one, is 72 feet. It is said that there pass daily over London bridge 89,640 foot passengers, 769 waggons, 2924 carts and drays, 1240 coaches, 485 gigs and taxed carts, and 764 horses.

Westminster bridge was begun to be built in the year 1738, and was finished in 11 years and 9 months, at an expence of nearly 400,000*l*. Its length is 1223 feet, and its width 44 feet. There are 13 large, and 2 small semicircular arches, and 14 piers. The middle arch is 76 feet wide, the two next 72, and the last 25. The whole open space for the water is 870 feet. The two middle piers contain about 200 tons of Portland stone. On the top of the bridge are 28 semi-octangular towers, 12 of which are covered with half domes. Westminster bridge is a beautiful structure, and seems to have been carefully and substantially built, as hitherto there is little or no appearance of decay in any part of it.

Blackfriar's bridge was begun in 1761, and finished in the year 1769. It was built by private subscription; but government afterwards bought up the shares, and threw it open to the public. It cost 150,840*l*. rather less than the estimate, and a very small sum even at that period. Its length is 1100 feet, and breadth 42 feet. It has 9 elliptical arches, and 8 piers. The centre arch is 100 feet wide, those on each side of it 93, the third 80, and the fourth 70. It has a remarkably light and elegant appearance; but it is decaying very rapidly. The stones of which it is built are too soft, and are scaling off near the water's edge. The ornamental columns at each pier will not stand many years. It is calculated that there pass over Blackfriar's bridge 61,069 foot passengers, 533 waggons, 1502 carts and drays, 990 coaches, 500 gigs and taxed carts, and 822 horses.

The Strand, or Waterloo bridge, is one of the noblest structures of the kind in the world, whether we regard the simple and chaste grandeur of its architecture, the impression of indestructibility which it forces on the mind of the beholder, or its convenience as a bridge. It was begun in the year 1811, and opened in 1817, on the anniversary of the battle of Waterloo. The architect was Mr. Rennie. It cost rather more than one million of money, all of which was raised by private subscription. It crosses the Thames near the Savoy, to the opposite shore of Lambeth Marsh. It contains 9 equal arches, each of 127 feet span. The piers are 20 feet high; the width within the parapets 42 feet, the foot-paths being 7 feet each, and the roadway 28 feet. It is perfectly flat, and is built of granite. It is intended to open streets on the Surry side to the Obelisk in St. George's Fields, and to Kennington.

The Vauxhall bridge, which was begun nearly at the same time as the Waterloo bridge, crosses the Thames from Milbank to the Cumberland tea gardens near Vauxhall. It consists of 9 arches of equal span of cast iron. The span is 78 feet, the height 29 feet, and the breadth of the roadway 36 feet; the length is 899 feet. It was built by private subscription. A road is opened from it to Pimlico, and thus it is connected with Hyde Park Corner. It cost nearly 300,000*l*.

The Southwark bridge is not yet finished. It crosses the Thames at the bottom of Queen Street, Cheapside, to Bankside. It consists of 3 arches of cast iron. The centre arch is 240 feet span, and the side ones 210 feet each. The river here is very narrow, but very deep and rapid. The estimate is 287,000*l.* The architect is Mr. Rennie. It is building by private subscription.

It is calculated that London contains 113 churches of the established religion, 66 chapels of ease, 11 Catholic chapels, 17 churches and chapels belonging to foreign Protestants, 6 synagogues, and 200 places of worship belonging to the various denominations of dissenters. Of the churches of the established religion, we shall notice only such as are remarkable for their external architecture or internal decorations.

Westminster Abbey, or the collegiate church of St. Peter, claims our first notice. It was built by Henry III. and finished, after 50 years labour, in the year 1220. Henry VII. built his chapel on the east side in 1502, at an expence of 14,000*l.* It was made a collegiate church by Queen Elizabeth in 1559, who, at the same time, founded the school. The length of the church is 360 feet, the breadth of the nave 72, and the length of the cross aisle 195 feet. There are 12 chapels at the eastern end, the most celebrated of which is that of Henry VII. This is deemed one of the finest specimens of the florid Gothic in the world. The entire roof is of wrought stone, finished in the most beautiful and delicate manner. The choir of the abbey is also remarkably beautiful; but the grand effect of the whole interior is much diminished, by the immense number of monuments (some of them in very bad taste) with which it is crowded. The one to Sir Isaac Newton by Reisback is fine; the statue of Addison is also good, though the attitude is rather affected. There are also too good figures in the front of the Duke of Argyle's monument. Some of those by Roubilliac and Bacon are among the best. Besides the monuments, there are to be seen the oak chairs in which the kings and queens of England are crowned; the stone on which the kings of Scotland were crowned at Scone, brought to England by Edward I. and a variety of figures in wax. In consequence of the action of the air on the soft stone, of which Henry VIIth's chapel was built, the external decorations were very much decayed. They are now, however, renewing with great skill and taste, exactly after the model of the originals. The prospect from the top of one of the western towers of the abbey is very beautiful, though not very extensive. The abbey itself is seen to great advantage from Hyde Park, its Gothic towers rising above the summit of the trees.

St. Paul's Church was first founded by Ethelbert, King of Kent, in the year 610. It was burnt in 1087, with most part of the city; but was built soon afterwards on stone arches. The steeple, which was finished in 1222, was set on fire by lightning in the year 1444; and was again burnt, together with all the roof, in 1561, by the negligence of a plumber. Lastly, the whole church, having been destroyed in the fire of London in the year 1666, was entirely rebuilt by Sir Christopher Wren. It was begun in 1675, and finished in 1761. The length of the church, including the portico, is 500 feet; the width 250; the summit of the dome is 340 high; the exterior diameter of the dome 145 feet; and the whole circumference of the building 2292 feet. It cost 736,752*l.* A ballustrade of cast iron, remarkable at once for its beauty and its strength, placed on a low stone wall, surrounds the church and church-yard, and separates them from a spacious carriage-way on the south side, and a foot-pavement on the north. The body of the church is in the form of a cross. The dome springs from the place where the lines of this cross intersect one another; and from the top of the dome rises a lanthorn, which is adorned with Corinthian columns, and surrounded at its base with a balcony. A ball, surmounted by a cross, crowns this part of the building. There are three porticoes, one at the principal enterance to the west, and the other two facing the north and the south, at the extremities of the cross aisle. The corners of the western front are adorned with turrets. The ascent to the principal entrance is by 22 steps of black marble, resting on a base, from which rise 12 lofty Corinthian columns, and eight Composite above. The impression made by the external appearance of St. Paul's is that which arises from a sense of grandeur and beauty conjoined; but though situated nearly in the centre of London, on an eminence, it is not seen to advantage as we approach it, in consequence of the narrowness of the streets, and the want of a sufficiently open space in its immediate vicinity. Perhaps it is seen to the greatest advantage from Blackfriars Bridge. Its interior is generally deemed naked and unfinished, and by no means corresponding with its exterior; but it is impossible not to be struck with its greatness, which rather gains by the want of ornaments. The interior part of the dome was painted by Sir James Thornhill; and, within these few years, several monuments have been been erected in honour of eminent literary, military, and naval characters. Under the centre of the dome, Lord Nelson was interred. There are several objects worth seeing in St. Paul's, besides those already mentioned, particularly the great clock on the southern side, the bell of which weighs 11,474 pounds, and is 10 feet in diameter; the model by Sir Christopher Wren, from his first design for this cathedral; the whispering gallery; the timber work, which strengthens at once the outer dome and the cone within it; and the crypts or vaults. The prospect from the outer gallery, at the foot of the lantern of the metropolis and the adjacent country, in a clear day, is uncommonly striking. See Plate CLXXIV. of this work.

The remaining churches worthy of notice are St. Stephen's, Wallbrook; St. Peter-le-poor, Broad Street; St. Martin's in the Fields, near the Strand; St. George's, Hanover Square: St Paul's, Covent Garden; St Mary le Strand; St. Michael's, Cornhill; St. Dunstan's in the East, Thames Street; St. Mary-le-bow, Cheapside; St. Bride's, Fleet Street; St. Margaret's, Westminister; and the new Church, near the Regent park, Mary-le-Bone.

St. Stephen's, Wallbrook, near the Mansion-house, is reckoned the master-piece of Sir Christopher Wren. It is only 75 feet long, and 36 broad, in the form of a cross. The interior is a perfect model of pure and chaste classical architecture, for grace, airiness, elegance, and the harmony of its proportions. The outside of this beautiful building is concealed and disfigured by shabby houses which are stuck against its walls.

St. Martin's, in the Fields, is remarkable for its very fine portico, the design of which was taken from an ancient temple. It cannot, however, be seen to advantage, on account, of the narrowness of the street in which it stands. The portico of St. George's, Hanover Square, though not nearly so beautiful or chaste in its style as that of St. Martin's, is yet deserving of notice. The architecture of St. Paul's, Covent Garden, which was built after the design of Inigo Jones, is distinguished by its uncommon simplicity, and proves what a strong and pleasing effect may be produced by mere simplicity, when guided by pure and correct taste. St. Mary's, in the Strand, is highly ornamented, but in such a manner as not to offend, but to produce one unmixed and undisturbed impression of gratification. The architect of this and of St. Martin's in the Fields, was Gibbs. The tower of St. Michael's, and the tower and spire of St. Dunstan's, principally distinguish these churches. St. James', in Piccadilly, has a beautiful baptismal font of white marble, by Gibbons; and St. Margaret's, Westminister, deserves notice for a painted window, at the eastern extremity. See Civil Architecture, Vol. VI. p. 641.

Next to the places for public worship may be noticed the principal public schools.

Christ's Hospital is a royal foundation, having been founded by Edward VI. in the year 1552. It is very extensive, but very irregular. The south front, which adjoins Newgate Street, is the best. But it is not as a building that Christ's Hospital deserves notice or praise; it is as a place of education. Its permanent revenues are derived from royal and private donations in lands and houses; a licence to carts granted by the city; a small duty on every piece of cloth brought to Blackwell Hall; and voluntary subscriptions. The income is about 44,000*l.* and the expenditure about 42,000*l.* A donation of 400*l.* makes a governor. There is accommodation for 1156. At Hertford there is a school for the younger part of the children: all the girls are educated at this school. The education and general treatment is excellent. Every year a certain number are apprenticed, or sent to the sea service. The boys wear the dress of the period when the school was founded.

The Charter-House, near Smithfield, was founded and endowed at the sole cost of Thomas Sutton, Esq. who purchased the house, in 1611, from the Earl of Suffolk for 13,000*l.* It was opened in October, 1814. The estate is now above 6000*l.* a-year. Eighty poor men are supported. There are 42 scholars on the foundation, and between 160 and 170 not on the foundation. This foundation also supports 29 students at the universities. The government is generally vested in some of the principal nobility, always including some of his Majesty's ministers. The education in this school is excellent, particularly as respects classical literature.

Westminster School, by the statute of its foundation, should educate 120 scholars, viz. 40 king's scholars, and 30 town boys; but there are generally upwards of 250 of the latter taken. The king's scholars are boarded and lodged. This school also is celebrated for its classical education. The revenue of St. Paul's school is nearly 5000*l.* per annum. The number of boys is limited to 153. In the Merchant-Taylor's School 215 boys are educated.

The Foundling Hospital may be noticed among the places of education. It is situated about a quarter of a mile to the north of Holborn, near Brunswick and Russel Squares. It was founded in 1739, through the zealous and benevolent exertions of Captain Coram, the master of a merchant ship. Its object is to receive, maintain, and educate exposed and deserted children. Its revenues are derived from landed and funded property, and from collections at the doors, and the rents of the pews of the chapel, and are said to be sufficient to maintain upwards of 400 children.

The Royal Military Asylum at Chelsea may also be noticed as a place of education. It was founded through the exertions of the Duke of York, in 1805, and cost 80,000*l.* The building is a fine specimen of simple and unadorned architecture. The object of this institution is the maintenance and education of the children of non-commissioned officers and privates of the regular army; it is supported by a small deduction from the pay of the soldiers, and by Parliamentary grants. There are generally between 800 and 900 boys, and between 400 and 500 girls, at Chelsea, besides 100 younger boys and girls at the Isle of Wight. The whole work of the house, as well as the making of their clothes, is done by the children, or the people who have the care and education of them.

Besides those public places for education, there are 237 parish charity schools, and about 30 schools on the systems of Bell and Lancaster. The Sunday Scholars alone are estimated at 40,000.

The institutions for the promotion of the various branches of science and the arts in London are numerous. Our limits, however, will admit only of a brief and rapid notice of a few of the most important and celebrated. The Royal Society holds the first rank. This meets every Thursday evening, nominally, at 8 o'clock, but often half an hour later; and separates precisely at 9, during its session, which is from the beginning of November till the conclusion of Trinity term. Its meetings are held in Somerset House. No strangers are admitted without the permission of the president and fellows present. A large library of books, a museum of natural history, and a variety of apparatus belong to this society. The upper end of the room in which the sittings are held is decorated with a full length portrait of Sir Isaac Newton, who was the first president of the society. For an account of the objects, rules, and transactions of this and the other institutions for the promotion of sciences and the arts, see Academy, and Society. The Society of Antiquaries likewise hold their meetings in Somerset House. Their meetings begin and end at the same time of the year as the meetings of the Royal Society. The chair is taken at half-past 7 every Thursday evening. Members have the privilege of introducing a friend. There are many curious and scarce remains of antiquity in the rooms where the meetings are held. The Society for the promotion of Arts, Manufactures, and Commerce, hold their meetings in their house in John's Street, in the Adelphi, every Wednesday at 7 in the evening, from the fourth Wednesday in October to the first Wednesday in June. Strangers may be present on the introduction of members. On the last Tuesday in May, when the medals are distributed to the successful candidates, the sight is very pleasing and interesting. This distribution takes place in the grand room of the society, the walls of which are ornamented with a series of paintings, by Barry, illustrating the advancement of man from ignorance and barbarism, to a state of knowledge and civilization. The various models, machines, &c. are well worth examination, and may be seen through the intervention of any member. The other societies of note of a similar nature to those just mentioned, are the Linnean Society, which holds its meetings in Gerard Street, Soho; the Geological Society, which holds its meetings in Lincolns-Inn-Fields; and the Horticultural Society. All these societies promote their respective objects, by publishing a selection of the papers which are read at their meetings.

The institutions, as they are called, are of a different nature; they promote science and literature by the lectures which are delivered at them, and by the libraries which are attached to them. The oldest and most celebrated is the Royal Institution. The house is in Albemarle Street, off Piccadilly. Lectures on the principal branches of science, on the fine arts and literature, are read here during the winter season. There is also a large and valuable library; a chemical laboratory, the apparatus of which is not excelled in any country for its magnitude and variety; and a reading room for newspapers and other periodical publications. It is supported by proprietors shares, lifeholders shares, and annual subscriptions. The London Institution was founded about five years after the Royal Institution, by merchants and other gentlemen in the city. Its present house is temporary, but a spacious and convenient one is building in Moorfields. Hitherto no lectures have been delivered, but the library is very valuable, especially in works on classical literature and British topography. The books belonging to those two institutions do not circulate, but may be consulted on the spot by any person through the intervention of a subscriber. The Surry Institution, and the Russel Institution—the former at the south end of Blackfriar's Bridge, and the latter in Great Coram Street, Russel Square, are somewhat similar to the Royal and London Institutions, but on a smaller scale. Lectures are generally delivered at the Surry Institution, and part of the books circulate. There are no lectures at the Russel Institution, but all the books circulate. The lectures delivered at Gresham College, once the Royal Exchange, by no means answer the intention of their founder, and are, in fact, almost useless. The lectures delivered in various parts of London, on medicine, surgery, and the sciences connected with them, are very numerous. It is calculated that nearly one thousand students attend these lectures and the hospitals annually.

The largest collection of antiquities, natural curiosities, natural history, and books, in the metropolis, is in the British Museum. This building in Russel Street, Bloomsbury, which formerly belonged to the Duke of Montague, is disposed round a vast court, and is in very good taste. The Museum owes its origin to Sir Hans Sloane, who bequeathed it to Parliament, on condition that 20,000*l.* was paid to his executors. It was first opened to the public in January 1759. The painted cielings on the stairs and halls, which are all by foreign artists, are very fine. Since the death of Sir Hans Sloane, the British Museum has been enriched by many valuable donations and purchases; the most important and valuable are, the Cottonian library, the Harleian manuscripts, Sir William Hamilton's antique vases, &c.; the Townleian, Elgin, and other marbles; Egyptian antiquities; Hatchet's and other minerals, &c. All parts of the Museum, except the library and the coins and medals, may be seen every Monday, Wednesday, and Friday, (except during August and September, and in Christmas, Easter, and Whitsun weeks,) between the hours of ten and four, without any difficulty, or other form, than the visitor merely entering his name, &c. in a book. This regulation was adopted only in 1810; previously there was much trouble and delay in procuring admission. The following statement, taken from the returns to Parliament, proves the advantage derived to the public from this new arrangement. In the year 1810-11, the first year of the new regulation, there were admitted to see the British Museum, 29,152 persons; whereas, in the year 1816-17, there were admitted 40,500 persons. The trustees alone can grant admission to the library, and this may be obtained by sending an application in writing to the principal librarian. The term of admission does not exceed six months, but it may be renewed. Leave from the trustees, or from the principal librarian, must be obtained, in order to see the coins and medals.

The British Museum is the only public collection of the kind in the metropolis; but there is an extensive and valuable collection of natural history belonging to Mr. Bullock in Piccadilly. The insects and smaller animals, as well as the birds in this collection, are very numerous, and some of them very rare, and all in excellent order and preservation. There are also curiosities from the South Seas, North and South America, &c. and some antiquities, in Bullock's Museum. To the lovers of natural history, the living animals which are exhibited at Exeter Change will prove a high treat. Those in the Tower are not nearly so numerous or rare.

In noticing the fine arts, the Royal Academy must be first mentioned. Its meetings are held, and the annual exhibition of its paintings takes place in Somerset House. Lectures are delivered to the students on anatomy, painting, sculpture, and perspective. The annual exhibition begins in May, at an admission of one shilling. The paintings, &c. are generally very numerous, but there are seldom many of great merit. The gallery of the British Institution, Pall Mall, generally contains a good selection of paintings of British or foreign artists; there are besides always open a variety of exhibitions of single pictures, or collections of pictures, to which admission may be obtained on the payment of a small sum. The principal private collections are those at the Queen's palace; the Marquis of Stafford's, which is very numerous; Lord Grosvenor's; Mr. Angerstein's, which, though small, is deemed the most select and valuable in London; Mr. Hope's; Mr. Knight's; Sir John Leicester's, chiefly of British masters. In general, there is little difficulty in gaining admission to these collections. The Marquis of Stafford's, indeed, is regularly opened every year.

The English have never been highly distinguished for their attachment to, or proficiency in, the other main branch of the fine arts—music. Latterly, however, it would seem more attention has been paid to it in the metropolis. Besides professional concerts, (which, as continually varying, cannot be noticed here) the Academy of Ancient Music, and the Concert of Ancient Music, or the King's Concert, may be noticed as regular and permanent institutions for the encouragement of this art, and the gratification of its admirers.

The libraries of the British Museum, and of the Royal and other Institutions, have already been noticed. The manuscripts and rare books of that of the first, are very numerous and valuable—the books belonging to the institutions are rather various and numerous than rare. We shall here add a brief notice of some other collections of scarce manuscripts and books. In Wakefield Tower, and White Tower, in the Tower, are vast numbers of records, and several state papers; these are now undergoing a careful revision. The King's library at St. James' is very valuable and numerous. At Lambeth Palace, Gray's Inn, Lincoln's Inn, the Temple, Zion College, St. Paul's School, there are many very curious books. In the Herald's Office is a curious collection of books and MSS. relating to heraldry, &c. The most magnificent and extensive private libraries, are those of

Earl Spencer and Sir Joseph Banks. The former is celebrated for old and rare editions; the latter for books on natural history.

The bookselling trade of London, it may well be conceived, is carried on on a very extensive scale. The following particulars are taken from the Picture of London, as from a source of as accurate information as can possibly be had. "Paternoster-Row, Ave-Maria Lane, and their vicinity, exhibit a kind of fair on the last night of every month, nearly 2000 parcels being packed and sent off by the coaches and waggons, containing from 50,000 to 60,000 numbers of monthly publications, besides books and pamphlets. About 800 new books and pamphlets are regularly published every year in the metropolis, amounting in value to about 300*l.* for one copy of each. The gross annual returns arising from the printing and selling of books are little short of one million sterling; and these trades furnish employment, in and near London, to nearly 2000 persons."

"The first circulating library was established in London about the year 1740," fifteen years after Allan Ramsay established one in Edinburgh. At present, there are few streets in the metropolis without a circulating library.

"The circulation of newspapers varies from 750 to 8000 a day, and they give employment to a great number of persons, in the characters of reporters, collectors of news, editors, translators, printers, newsmen. Of the morning papers, there are sold together about 16,000 daily; of the daily evening papers, between 11,000 and 12,000; and of those published every other day, about 10,000. There are also about 26,000 sold of the various Sunday papers, and about 20,000 of the other weekly papers. In all, the enormous number of about 250,000 copies per week; affording employment and subsistence to about 50 writers and reporters, 300 printers, 100 venders, and 100 clerks and assistants; besides paper makers, stationers, type-founders, &c. full 200 more.

The following statements, taken from papers laid before Parliament, will throw further light on this subject, one of the most curious connected with the metropolis,—itself, to those who explore it minutely, a constant source of wonder and astonishment:

An account of the Number of Newspapers sent by the Clerks of the Roads at the General Post Office, London, during three months, ending the 1st of February, 1815.

Daily Morning	17,765
—— Evening	212,639
Alternate days	90,016
Weekly	74,120

Sent beyond seas, by agents at the post office, during the same period:

Daily Morning	35 334
—— Evening	42,054
Alternate days	17 825
Twice a-week	8,091
Weekly	8,386

In the year 1814 there were sent to

	Daily Papers.	*Alternate.*	*Twice a Week.*	*Weekly*
France	153,620	24,429	13,359	11,841
To Spain, Italy, Germany, and the north of Europe	192,047	28,598	18,682	13,544
To the Mediterranean and the Brazils	215,762	30,105	25,395	13,633

For a full account of the hospitals at Greenwich and Chelsea we must refer to those articles. A brief notice of them, however, may be expected in this place.

Greenwich hospital, which was founded by William III. is, without doubt, the most magnificent building in London or its vicinity; and the effect produced by it is much heightened by its vicinity to the river, and by the fine grounds that lie behind it. There are upwards of 2400 in-pensioners, and 3000 out-pensioners, besides a school, in which 200 boys are clothed, fed and educated.

The infirmary is calculated to hold 256 patients. Chelsea hospital, though a handsome building, and pleasantly situated, is by no means to be compared to Greenwich hospital in either of these respects. There are between 500 and 600 in-pensioners, and generally nearly 20,000 out-pensioners.

Besides these two national hospitals, there are 22 other hospitals, and asylums for the sick and lame, and for pregnant women, in the metropolis; 107 almshouses; 17 dispensaries; and 18 institutions for the maintenance of indigent persons. Of the hospitals, properly so called, Bartholomew's, St. Thomas', Guy's, Bethlehem, and St. Luke's, are the principal and most extensive. Bartholomew's hospital was founded by Henry I. reformed and endowed by Henry VIII. and incorporated by Edward VI. It was rebuilt in the year 1729. It is rather a handsome and magnificent building of stone, between Christ's hospital and Smithfield. There are some paintings in it by Hogarth and Reynolds. All indigent persons, maimed by accident, are received into this hospital, at all hours of the day and night, without previous recommendation. Any person labouring under any complaint is received only on petition, signed by a governor. There are besides always a number of out-patients. The medical and surgical attendance and advice is of the very best description. There are on an average about 4000 in-patients, and as many out-patients, attended annually. The lectures and attendance in the hospital afford an excellent school for young men intended for the medical profession. St. Thomas' hospital, which is situated in the Borough, near London Bridge, was founded by Edward VI. in the year 1552. The present building was erected in 1669 by subscription. It is under the direction of the Lord Mayor and livery of London. The mode and rules of admission are the same as at Bartholomew's. The out-patients are generally more numerous than at the latter hospital, but there are never nearly so many in-patients. It is equally celebrated as a medical school for its lectures and hospital attendance. Guy's hospital, which is close to St. Thomas', was built and endowed, in the most liberal manner, solely by Thomas Guy, a bookseller in London. It is a magnificent building, the hospital itself consisting of two quadrangles joined by a cross building. Patients are received only once a week. It can accommodate 320 in-patients at one time; and about 2000 out-patients are generally attended annually. It is also an excellent school of medicine. Bethlehem hospital was built in the year 1676, at the expence of 17,000*l.* in Moorfields; but this building has been taken down, and a new hospital erected in St. George's Fields, at the expence of nearly 100,000*l.* The income of this hospital in the year 1814 was upwards of 20,000*l.* the expenditure rather more than 19,000*l.*

From 1808 to 1814 inclusive, there were admitted 645 curable patients, and 36 incurables. St. Luke's was built by voluntary subscription in 1751, also for the reception and cure of lunatics. It is situated in Old Street, on the west side of the City Road. Both it and Bethlehem new hospital are large and handsome buildings. The income of St. Luke's, in the year 1814, was 10,054*l.* which was so inadequate to the expenditure, that the governors were obliged to take 3*l.* from each patient not receiving parochial relief, and 6*l.* from each patient who did receive such relief. About 300 patients are admitted annually. The other principal hospitals in London are, St. George's, near Hyde Park corner; the London hospital in White chapel; Middlesex hospital in Berner Street; the Westminster hospital in York Street, Westminster; the Lock hospital in Grosvenor Place; and the small-pox hospital. There are 15 principal dispensaries, besides smaller ones, extending from Chelsea on the west to Limehouse on the east, and from Islington and Somer's Town on the north, to Lambeth on the south, including nearly 50 square miles. It is calculated, that upwards of 50,000 poor persons are thus annually supplied with medicine and advice gratis, either at the dispensaries, or at their own houses. There are also 12 lying-in hospitals and institutions, besides numerous private societies for supplying lying-in women with child-bed-linen, &c. The other charitable institutions are commonly enumerated, or at most very briefly noticed. The Magdalene hospital in St. George's Fields, and the London Female Penitentiary in Pentonville, are for the relief and amendment of women of the town, &c. The Asylum for Female Orphans, is intended to prevent prostitution; it is situated in St. George's Fields. The School for the Indigent Blind in St. George's Fields, and the Asylum for the Deaf and Dumb in the Kent Road; the Society for the relief and discharge of persons confined for small debts, in Craven Street, Strand; the Society for bettering the condition of the Poor, in Piccadilly; the National Vaccine Society, the principal house of which is in Leicester Square; the Society for the relief of Foreigners, in Bedford Street, Bedford Row; the Refuge for the Destitute, Hackney Road; all sufficiently proclaim their respective objects by their names, and are of great service, and in general extremely well managed. The Philanthropic Society in St. George's Fields was instituted for the purpose of uniting the purposes of charity with those of industry and police; there are generally about 150 boys and girls taken from the prisons, &c. who are educated and taught different trades. The object of the Humane Society is the recovery of persons apparently drowned. The object of the Scottish hospital is to relieve and send home distressed natives of Scotland. Connected with this is the Caledonian Asylum, lately instituted; its object is to educate and support the children of poor Scotch people. The Benevolent Society of St. Patrick relieves the distressed natives of Ireland; and the Society of Ancient Britons educates the children of poor Welch people. The object of the Literary Fund is to relieve the distresses of authors and men of letters.

The following is a summary account of the institutions, &c. for the improvement and relief of the inhabitants of the metropolis:

"There are 407 places of public worship.

4050 Seminaries for education, including 237 parish charity schools.

8 Societies for the express purpose of promoting good morals.

12 Societies for promoting the learned, useful, and polite arts.

122 Asylums and alms-houses for the helpless and indigent.

30 Hospitals and dispensatories for sick and lame, and for delivering poor pregnant women.

704 Friendly or benefit societies, and institutions for charitable and humane purposes.

There are also upwards of 30 institutions for teaching many thousands of poor children reading, writing, and arithmetic, on the plans of Lancaster and Bell."

It is calculated that these institutions, including the poor's-rate, are supported at nearly one million per annum.

When we reflect on the immense population of the metropolis, and the crimes that are created or fostered, or which seek for their objects or for concealment in the midst of such a population, we shall not be surprised at the complaints which are so often made of the prevalence of crimes of all descriptions in London, nor that the prisons are always so crowded with a most abandoned and wretched race of people. The prisons in the metropolis, indeed, must be an object of considerable interest on many accounts, especially because, from investigating the management and discipline pursued in them, we may form some idea in what manner one of the most sacred duties of government, the prevention and efficient punishment of crime, is performed. Very lately, the prisons of the metropolis have attracted the notice of Parliament, as well as of several humane, enlightened, and zealous individuals; and it is to be hoped, that by their efforts the management and discipline of them will be rendered more effectual towards the prevention of crime, and the reformation of the criminals.

The principal prison in London is Newgate. It was first built about the reign of Henry I. or Stephen, and rebuilt in 1412. It was afterwards repaired in 1631, and rebuilt in 1672. In 1777 it was again rebuilt on a more improved plan; but in 1780 this prison was almost destroyed by the rioters. Great improvements were made on it when it was repaired. The outward appearance is rather grand, and answers very well to the idea of a prison. It consists of two wings, the debtors and the felons side, with the keeper's house in the middle. It is intended, however, to remove the debtors to a new prison in Cripplegate. Felons for trial, and convicts, are confined in the centre and eastern yards. Felons under sentence of death are kept in the condemned yard, which is in the north-east corner. In the other yards, convicted felons are lodged. The felons are generally between 200 and 300 in number. Single rooms in the state side of the prison, or in the governor's house, are left to such prisoners as can afford and are willing to pay for them. The King's Bench prison is situated in St. George's Fields. It is a very extensive and commodious building. There are 224 rooms about 14 or 16 feet by 12 or 13; eight of these are state rooms, that are let unfurnished at 2s. 6d. a-week. Within the walls of this prison are several shops, and the whole has the appearance of a small village: it is surrounded by walls 30 feet high. The rules or liberties of this prison are very extensive, comprehending a circuit of nearly three miles round it. The Fleet prison is situated on the east side of Fleet market. It was first made a prison in the reign of

Richard I. Having been destroyed by the rioters in the year 1780, it was rebuilt, but it is still an inconvenient prison, and the situation is low. It is a prison for the confinement of debtors, and such as are committed for contempt of court. There are 109 rooms, 89 of which receive *chums*; 15 are allotted to poor prisoners with large families; the rooms are 14½ feet by 12½. The number of the prisoners is generally between 200 and 300: they are allowed to exercise and amuse themselves in a large court. The rules of this prison extend a very short way from it. The principal other prisons are, the Gilt-Spur Street Compter, for persons committed for further examination, or for trial; the Debtors prison, Cripplegate; the Middlesex House of Correction in Cold Bath Fields, constructed on the plan of Mr. Howard, at an expence of nearly 80,000*l*. There are 218 cells, each eight feet three inches long, by six feet three inches wide. The New prison, Clerkenwell; Tothilfields, Bridewell; the Borough Compter; the New Gaol in the Borough; the Marshalsea, and the Penitentiary House, Milbank. The last is intended for such culprits as used to be sent to New South Wales for a shorter period than the duration of their lives; they are confined in circular buildings, constructed in such a manner, that the overseer from a room in the centre may be able to see them all; the building is not yet finished.

The following statement, taken from papers laid before the House of Commons, will afford some idea of the number of criminals in the metropolis under the age of 20 years.

In the year 1816, there were in the prisons under that age 1683 criminals; viz. 1357 males, and 326 females; of 17 years and under, there were 1281, viz. 1017 males, and 264 females; of 17 years and under for felonies, there were 957, viz. 788 males, and 169 females.

We must now consider London as the seat of Government, and the supreme administration of the law. Besides the public offices of Government for the management of its civil, military, naval, and financial concerns, there are nine supreme courts of justice; 38 inferior courts; four ecclesiastical courts; 12 inns of court for the study of the law; and above 8000 lawyers who practice in the several courts.

Under the roof of Westminster Hall, are the High Court of Chancery, and the Court of King's Bench, the Court of Exchequer; the Court for Insolvent Debtors; and the Houses of Lords and Commons. Westminister Hall, strictly so called, was built by Willian II. in the year 1097. The courts of law were first fixed here in 1224. The hall is the largest room in Europe, unsupported by pillars, with the exception of the theatre at Oxford; it is 275 feet long and 74 broad; it is only used during trials on impeachment. The Court of Chancery is at the upper end of the hall; but during the vacations the Lord Chancellor sits at Lincoln's Inn Hall, Chancery Lane. The courts of the Vice Chancellor, and of the Master of the Rolls, are also in Chancery Lane. The Court of King's Bench is opposite to the Court of Chancery, in Westminster Hall; few capital offences, however, are tried here; there are four judges in this court, one of whom is called the Chief Justice. The Court of Exchequer is on the right side of Westminster Hall, near the entrance; there are four judges in it. The Court of Common Pleas, which is confined to civil cases, is in the middle of the hall, on the right side; there are four judges in it, one of whom is styled the Chief Justice. After each of the terms, of which there are four in the year, the judges of the King's Bench, Court of Exchequer, and Court of Common Pleas, try special causes not only in Westminster Hall, but also in Guildhall. The House of Lords by no means answers the idea that strangers will naturally be led to form of it, when they consider it as the place of assembling of one of the branches of the Legislature. It is not splendid, or sufficiently large for the purpose. The walls are decorated with tapestry, representing the defeat of the Spanish Armada; at the upper end is the throne; the Lord Chancellor and Judges sit on woolsacks; and the Peers sit on benches covered with baise; at the bottom of the room is a lobby for strangers, or for the members of the House of Commons, when they come up to the bar of the House. The regular mode of admission for strangers, is by an order from a Peer; business usually commences about five o'clock. When the King goes in person at the opening or close of a session, the Lords are dressed in their robes. Ladies in full dress are admitted, and the whole effect is very grand. The House of Commons was formerly a chapel, dedicated to St. Stephen; hence it is sometimes even yet called St. Stephen's chapel. On the Union with Ireland, the house was enlarged, but it is still too small, and by no means convenient. At present, however, it is undergoing alterations, which will render it much more commodious for the admission and accommodation of strangers. The room is about 60 feet by 40, with three windows towards the Thames at one end; the public gallery for strangers faces the windows, and is about 18 feet above the floor; there is a narrower gallery on each side for the members. The chair of the Speaker faces the gallery; five rows of benches covered with green leather, are disposed in the form of an amphitheatre round the room. The right of the Speaker is occupied by the ministers and their adherents, the left by the opposition. Strangers are admitted either by an order from a member, or by money given to the doorkeepers; but as the gallery is very small, it is necessary to be there whenever an interesting debate is expected, sometimes as early as 10 or 12 o'clock. The regular business seldom commences before four or five o'clock.

The great public departments of Government have their respective offices in Whitehall, or the streets leading out of it. At the head of these departments is the Treasury. The building so called is very extensive, but by no means handsome, with the exception of the front towards the Park, and certainly very inconvenient.

Every thing relating to the management and control of the revenue is transacted at the Treasury. The office of the Secretary of State for the Home Department adjoins the Treasury; it formerly belonged to the Duke of Dorset. At this office is transacted every thing relating to the police, and internal administration of the country. The offices of the other two Secretaries of State, the Foreign and Colonial, are situated in Downing Street; the buildings of each are plain, but sufficiently extensive and convenient; the respective names of each office sufficiently point out their objects. The Horse Guards, which contains the offices of the commander in chief, the secetary at war, the adjutant-general, and the quarter-master general, is situated at the east end of St. James' Park; it is a handsome building of stone. There are generally in London and its immediate vicinity, three regiments of foot guards, amounting to upwards of 10,000 men: two regiments of horse guards, amounting to 1200 men, and about 100 yeomen of the guard. The principal barracks of the foot soldiers are in Knightsbridge; and for the horse, on the south side of Hyde Park. A little nearer Charing Cross than the Horse Guards, is the Admiralty, which is at the head of all the departments connected with the navy; it is a very extensive building, containing not only the necessary offices, but also houses for the Lords of the Admiralty, &c. On the top of the building there is a telegraph, which communicates with Deal, Yarmouth, Portsmouth, &c. The council-chamber is under the same roof as the Treasury. The Board of Control was also there till very lately, when it was removed to the building in Cannon Street, Westminster, formerly occupied by the Transport Office.

There is another assemblage of public offices at Somerset House, which has been already incidentally mentioned as containing the apartments of the Royal Academy. This building, the front of which faces the Strand, is not destitute of elegance and of architectural taste: but it is more remarkable for the solidity and completeness of the workmanship. The terrace which fronts the river is very spacious, and the whole of this part of the building appears to great advantage from Waterloo Bridge. The grand entrance by three lofty arches leads from the Strand into a spacious quadrangle. The building, according to the original plan, is not yet completed. The navy, navy-pay, and victualling offices, are in Somerset Place, and likewise the offices of the auditors of imprest, commissioners of hackney coaches, and hawkers and pedlars, stamps, lottery, &c. The Tower of London may be noticed and described in this place. The White Tower was built by William the Conqueror in 1078, and in 1190 it was surrounded by a wall and a ditch. It was almost new built in 1637-8. Wild beasts were first kept here in 1235. Gold was first coined there in 1344, and criminals were first executed on Tower Hill in the year 1466. The Tower is an irregular assemblage of buildings of various sorts, surrounded by a wall and large moat full of water, in a circumference of about 1200 feet, forming an area of three or four acres. Its site being rather elevated, it overlooks the town and the river. The principal buildings within the Tower are, the church, the white tower, the ordnance office, the record office, the jewel office, the horse armoury, &c. The armoury is the most striking sight in the Tower; the room in which it is contained is 345 feet long, and there are frequently upwards of 150,000 stand of arms, kept in the best possible order, and arranged with great taste. There, is besides, the Spanish armoury, consisting of the spoils of the Armada; the Sovereigns of Great Britain from William the Conqueror to George II. in their real armour; the jewels of the Crown; and the menagerie. State prisoners are confined in the Tower.

Of the Inns of Court, the Temple is the most ancient and the most celebrated. It was founded by the Knights Templars in the year 1185; and, on their suppression in 1310, Edward III. gave it to the Knights of St. John of Jerusalem: they soon afterwards leased it to the students of the law, in whose possession it has continued ever since. It is divided into two societies of these students, called the Inner and Middle Temple. The whole range of building which goes under the name of the Temple is very extensive, as it stretches north and south from Fleet Street to the river, and east and west from Lombard Street, Whitefriars, to Essex Street in the Strand. There are two entrances from Fleet Street, one to the Inner, and the other to the Middle Temple. The garden of the former, on the banks of the river, is uncommonly pleasant and well kept. The Temple church is a good specimen of the Norman style of architecture.

The halls of both the Inner and Middle Temple, but especially of the latter, are very spacious and elegant. The government of the whole is vested in the benchers. Lincoln's Inn is the next in importance to the Temple: it was so called from being the inn or town house of Henry Lacy, Earl of Lincoln, who died there in the year 1310. Most of the buildings are old and irregular; but the stone buildings, as they are called, that front the west, with a beautiful garden before them, and Lincoln's Inn Square beyond, are elegant and convenient. The garden in summer is open to the public, and is a fashionable and pleasant promenade. The whole of Lincoln's Inn, as well as the other inns of court, are let in chambers or floors. Gray's Inn, on the north side of Holborn, was a house belonging to the Grays of Wilton, who resided there from 1315 till the reign of Edward III. when they demised it to the students of law. The other Inns require no particular notice. Furnival's Inn in Holborn is at present rebuilding. Doctor's Commons is situated to the south of St. Paul's church-yard. It consists principally of two squares: there are five courts in it; the court of arches, admiralty, prerogative, delegates, and consistory.

Having thus considered London as the seat of the government of The British empire, we are now to view it with respect to its jurisdiction as a city. We must bear in mind that London, in the usual and most extended acceptation of the word, comprehends not merely the city of London and its dependencies, but also the borough of Southwark, and the adjacent parishes in Surry; the city and liberties of Westminster, and several parishes in Middlesex. Before we proceed to the consideration of the civil government of the city of London, we shall notice the government of the borough of Southwark, &c.

We have already mentioned, that the borough of Southwark is divided into two parts, called the Borough Liberty, and the Clink. The former is reckoned one of the wards of the city of London, and is called Bridgeward Without. It is under the jurisdiction of the Lord Mayor, who is its bailiff, having an alderman, steward, and deputy bailiff. The Clink is under the control of the Bishop of Winchester, who, by his steward, keeps a court leet and a court of record on the bankside. A court of conscience is also established here. The out-parishes in Middlesex and Surry are under the jurisdiction of the justices of the peace for these counties, as well as of the justices of the police offices, which are situated in them, as will be noticed afterwards. The government of the city and liberties of Westminster is under the jurisdiction of the dean and chapter of Westminster, in civil as well as ecclesiastical affairs; but the civil part has long been in the hands of laymen, selected and confirmed by the dean and chapter. The principal magistrate is the high bailiff, usually a nobleman: he is chosen for life; a deputy steward, chosen by the high steward; and a high bailiff, nominated by the dean, and confirmed by the high steward. There are also 16 burgesses, and a high constable.

The civil government of the city of London, properly so called, and its dependencies, is vested in the corporation, which consists of the lord mayor, the sheriffs, the aldermen, and the common council. The lord mayor and sheriffs are chosen annually by the livery, the former on the 29th of September: he does not, however, enter on his office till the 9th of November. The sheriffs have jurisdiction not only in the city, but also over the whole of the county of Middlesex: they enter on their office on the 29th of September. The aldermen are chosen for life, by such of the householders of the wards as are freemen. There are 25 wards. The aldermen are the principal magistrates in their respective wards; and with the lord mayor, the recorder, and the common sergeant, sit as judges to try capital offences and misdemeanors at the Old Bailey. The common council consists of the lord mayor, 25 aldermen, and 236 members: the latter are chosen annually by the freemen householders. No ward can have more than twelve, nor any fewer than six. The livery are the freemen of the different trades or companies. Many of these are extremely rich in landed property. Among the most wealthy are the mercers, grocers, drapers, fishmongers, goldsmiths, merchant tailors, ironmongers; all of which companies, besides several others, possess magnificent halls. The official residence of the lord mayor is in the mansion-house at the east end of the Poultry: it is a heavy, inelegant building, only it contains some magnificent apartments, especially the Egyptian Hall. The allowance to the lord mayor is 8000*l.* per annum. Guildhall, at the top of King Street, Cheapside, is the place where the meetings of the corporation of London are held. It is a fine Gothic building, all of which, except the front, was built soon after the fire of London: the front was finished in 1789. The hall, in which the meetings of the corporation are held, is 153 feet long, 48 broad, and 55 high. There are several monuments and paintings in it.

The police of the metropolis is on a very extensive plan, and upon the whole is very well managed and efficient. The head police office is in Bow Street, Covent Garden, which is under the immediate direction of the secretary of state for the home department. There are also police offices at Queen's Square, Westminster, Marlborough Street, Hatton Garden, Worship Street, Lambeth Street, Whitechapel, High Street Shadwell, and Union Street in the borough. The office at Wapping, is for offences connected with the shipping and port of London; for the same object, there is a floating police establishment in a ship moored in the Thames. The whole number of people employed to preserve the peace and safety of the metropolis and its suburbs, including Watchmen and patroles, is reckoned at 3077. By an act of Parliament passed in the year 1794, two regiments of militia are raised in the city, amounting to 2200 men: One must always remain in London, the other may be marched to the distance of 12 miles from it.

The city of London returns four members to Parliament. This privilege was conferred in the 49th year of Henry II. and the right of election is vested in the livery, who consists of about 10,000 voters. Southwark returns two members to Parliament; this privilege was conferred in the 23d year of Edward I. The right of election is vested in the inhabitants paying scot and lot, who amount to about 11,000. Westminster also returns two members to Parliament. This privilege was conferred in the 1st year of Edward VI. and the right of election vested in the inhabitants paying scot and lot, who amount to nearly 14,000.

It still remains, to consider London, under its most important and striking character, as the greatest commercial city in the world. The west end of the town, that is, all to the west of Charing-Cross, is inhabited by the nobility and gentry, and those dependent on them for employment, or occupied in the government offices. The city, or the principal trading part of the town, extends from Charing-Cross to the east end of Leadenhall Street: to the east of this street, the inhabitants are those of a sea port, in their manners, employment, &c Southwark is chiefly inhabited by wholesale and retail provision merchants.

The commerce of London, in its most extended sense, may be divided into three parts: First, the commerce, strictly so called, or the trade of the metropolis with foreign countries, and with other parts of Great Britain and Ireland: connected with this, may be considered the shipping: Secondly, the principal manufactories that are carried on in London; and, thirdly, the retail trade. Before we consider the commerce of London, in the strict acceptation of the word, as it at present exists, it may be proper to give a few short notices of its state at former periods, so that its progressive increase may be seen.

When the seige of Calais was about to be undertaken, in the year 1346, the various sea ports in England were obliged to furnish a certain number of ships and mariners to carry it on: at that period, London furnished only 25 ships and 662 men, while Dunwich in Suffolk, a place scarcely known at present, furnished 43 ships and 1095 men; Fowey 47 ships, and 770 men; Dartmouth 31 ships, and 757 men; and Plymouth 26 ships, and 603 men. And even so late as the middle of the 16th century, there were not above four ships that were above 120 tons each, (besides those of the royal navy,) within the river Thames. At the end of this century, the commerce and shipping of London must have increased considerably, for ten ships were furnished by the merchants to oppose the Spanish Armada. In the year 1613, London paid in customs 109,572*l.* 18*s.* 4*d.* and all the out ports only 38,502*l.* 9*s.* 4d.; or little more than one-third of what London paid. In the year 1710, according to Davenant, the proportion of the amount of customs received at the port of London was considerably above three and a half to one, compared to the customs received at the out ports; the former being 1,268,095*l.* and the latter 346,081*l.* hence it appears, that the custom duties both of London and the out ports had increased nearly ten-fold in about the period of a century. Between Christmas 1727, and Christmas 1728, there arrived at the port of London 8889 vessels, of which 6837 were coasters, and 2052 from abroad. In the year 1732, there belonged to the port of London 1417 vessels, from 15 to 750 tons, containing 178,557 tons, and navigated by 21797 men, and of these ships, there were 130 from 300 to 500 tons; and 83 from 200 to 300; all the rest were under 200 tons, except one ship belonging to the South Sea Company, of 750 tons. In the beginning of the present century, (30th September, 1800,) there belonged to the port of London in the foreign trade, 1810 vessels, the tonnage of which amounted to 503,676 tons, and they were navigated by 37,046 men; and in the coasting trade, there were 856 vessels, of 64,586 tons, and navigoted by 4356 men. The same year, the following were the proportions of the commerce of England, at London, and the out ports.

	Imports.	Exports.	
		British Merchandize.	Foreign Merchandize.
London	*L*18,843,172 2 10	13,272 494 0 5	12.156,428 16 2
Out ports	9,514,642 11 10	9,183,066, 9 11	6,192,960 11 4

Hence it appears, that London at this time had nearly two-thirds of the commerce of all England; and as the total imports of England and Scotland were 30,570,605 : 6 : 4; and their total exports were 43,152,19 : 5 : 6, London possessed considerably above one half of the whole commerce of Great Britain.

The following Tables will still further illustrate the progressive increase of the commerce and shipping of London till the beginning of the present century.

A State of the Customs of England, &c.

	The total amount of the Customs of England.			
1613	At the Port of London, Outwards	L 61,322 16 7		
	Inwards	48,250 1 9		
			L 109,572 18 4	
	At all the Out Ports, Outwards	L 25,471 19 7		
	Inwards	13,030 9 9		
			38,502 9 4	
	N. B. Very near three to one in favour of London.			148,075 7 8
1666	The farm of the customs of England, as stated by Davenant, was only per annum			390,000 0 0
1671 to 1688	The customs in England produced, in 17 years, as stated by Davenant, *L*9,447,797, or on an average per annum.			555,752 0 0
1700 to 1714	The net revenue of the Customs in England, on an average of 15 years, was, per annum			1,352,764 0 0
1709	The gross customs of Great Britain were,		2,319,320 0 0	
	Deduct drawbacks, charges, &c.		965,837 0 0	
				1,353,483 0 0
1711	The amount of the customs received, as stated by Davenant, in the port of London		2,319,320 0 0	
	Out ports		346,081 0 0	
				1,614,176 0 0
1792	The gross amount of the customs for the port of London may be estimated at about		3,580,000 0 0	
	Deduct drawbacks, charges, &c.		1,350,000 0 0	
				2,230,000 0 0
	The gross customs of Great Britain may be estimated at about			6,040,000 0 0
	The net customs of ditto, paid into the exchequer, may be estimated at about			3,980,000 0 0

Value of Imports and Exports.

IMPORTS OF ENGLAND.

Years.	Value.	Of which for London.	For the rest of England.
1697	*L*3,482,586		
1700	5,970,175	*L*4,785,548	*L*1,184,637
1737	7,073,638	5,335,254	1,738,424
1756	7,961,603	5,333,257	2,628,346
1763	11,665,036	8,146,417	3,518,619
1784	14,119,369	10,314,872	3,804,497
1791	17.688.151	12,016 229	5,671.822
1792	17,897,700	12,071,674	5,826,326

EXPORTS OF ENGLAND.

Years.	Value.	Of which for London.	For the rest of England.
1697	*L*3,525,909		
1700	7,302,716	*L*5,387,787	*L*1,914,929
1737	11,842,320	7,362.367	4.479,953
1756	12,517,640	8,347,100	4,170.540
1763	16,160,181	9,389 570	6.770,611
1784	14,804,161	8,260,278	6,543.883
1791	21,435,459	12,944,192	8,491,267
1792	23,674,315	14,742.516	8,831,799

EXPORTS AND IMPORTS OF GREAT BRITAIN.

Years.	Imports.	Exports.
1791	*L*19,669.782	*L*22,731,995
1792	19,659,358	24,905,200

State of Shipping &c.

Years.		*Ships.*	*Tons.*
1728.	Ships arrived in London from foreign parts, of which were British	1839	
	Foreign	213	
		2052	
	Coasters.	6837	
		8886	
1732.	The number of ships belonging to the Port of London, taken from the register of the Customhouse, were—1417 ships from 15 to 750 tons, making		178,557
	Navigated by 21,797 men.		
	Of these 1 was of . . . 750 tons.		
	130 were from 300 to 500		
	83 . . . . 200 300		
	The remainder under 200		
1742.	The number of ships employed at Bristol in foreign trade, including that to Ireland, were	400	
	At Liverpool, ditto ditto	300	
	N. B. Both are exclusive of coasters.		
1753	The number of ships cleared from ENGLAND were—British	7957	613,700
	Foreign	355	41,254
		8312	654,954
	Of which for LONDON were—British	1216	153,969
	Foreign	150	26,281
		1369	180,250
1792.	The number of ships cleared out from the Port of London for foreign parts were—British, about	1700	
	Foreign	500	
		2200	
	Of about (and exclusive of coasters)		399,000
1792.	The number of ships belonging to the port of London were about	1860	
	Tonnage		374,000
	Of these about 24 were from 500 to 750 tons		
	260 . . . 300 .. 500		
	360 . . . 200 .. 300		

At present, the total amount of the value of all the property that is imported into London, or exported from it, including both the coasting and foreign trade, is estimated at nearly 70,000,000*l.* annually; of which the import coasting trade is nearly 5,000,000*l.* the export coasting trade about 8,000,000*l.* the foreign import trade about 30,000,000*l.* and the foreign export trade about 27,000,000*l.* The two greatest branches of the foreign trade are those of the East and West Indies. Of the former, there are goods to the amount of upwards of 3,000,000*l.* exported, and nearly 5,000,000*l.* imported. The imports of the West India trade amount to upwards of 8,000,000*l.* and the exports to nearly 4,000,000*l.* The number of ships and amount of tonnage required to carry on all the trade of London may well be conceived to be immense. On an average of some years, the exports and imports have employed upwards of 4000 vessels; and the coasting trade nearly 9000: the outward and inward tonnage averaging, on the whole, nearly 1,800,000 tons. In the course of the year, there generally arrive about 14,000 vessels, including their repeated voyages. The number of vessels belonging to the port of London, on an average of some years back, amounts to nearly 3000, of about 600,000 tons, and navigated by about 45,000 men. About one-sixth of the tonnage, and one-fourth of the men, are employed in the East India trade; and about one-fourth of the tonnage, and one-third of the men, in the West India Trade. Of the coasting trade, that from Newcastle, &c. with coals, is the most extensive. The colliers, by their repeated voyages, exceed, in number of ships and tonnage, that employed in the foreign trade. The importation of coals, on an average of seven years preceding 1732, was 474,717 chaldrons; it now amounts to about 900,000 chaldrons per annum, the value of which may be estimated at nearly 1,800,000*l.* There generally arrive in the course of the year about 4500 vessels with coals.

The river navigation also employs a great number of vessels of different descriptions; there being generally about 3000 barges, about 350 punts, &c. which with hoys, &c. are estimated to make the total tonnage employed in the river navigation about 110,000. The number of wherries is about 3000, and there are about 8000 men employed in navigating them and the other small craft.

We must now briefly consider the river by means of which this immense traffic is carried on. The port of London, in the legal definition of the term, extends from the North Foreland, in Kent, and Shoeberry Ness, on the cast of Essex, (four miles north of Sheerness) to London Bridge: but the jurisdiction of the corporation of London, in whom is vested the conservancy of the port, reaches only to Gravesend, on the Kent side, while, on on the Essex side, a stone a little above Southend marks the limits of its jurisdiction. The port of London, as far as regards the loading and discharging of ships, is confined to the reach of the river between Deptford and London bridge, a distance of about four miles, with a breadth of from 400 to 500 yards. This space may be considered as consisting of four divisions; the Upper Pool, which extends about 1600 yards below London bridge; the Middle Pool, which extends from thence to Wapping new stairs, about 700 yards; the Lower Pool, which extends from Wapping to Limehouse, about 1800 yards; and the space below to Deptford, about 2700 yards. As far as Deptford, the Thames is navigable for vessels of almost any burden, though it is usual for Indiamen to take out a part of their cargoes in Long-reach; to the Lower Pool for vessels of 400 tons; to London Bridge for those of 200 tons; and nearly 180 miles above London Bridge for large barges. The tides flow up the Thames to the distance of nearly 80 miles from its mouth, at the rate of about eight miles in four hours; but the water is not salt higher than Gravesend, about 30 miles below London Bridge. At Gravesend, the river is about a mile broad, and at London about a quarter of a mile: at low water, it loses about one-third of its breadth. The spring tides rise about 18 or 20 feet; the neap tides 12 or 14 feet. The tide ebbs about seven hours, and flows about five hours. On the London, or north side of the river, is the deepest water. It is difficult to form an estimate of the number of ships that can or do lie in the river at one time, as it depends greatly on peace, war, seasons, and the nature of particular trades; but they seldom exceed from 1100 to 1400 sail at a time, including colliers and coasters. At times, there have been nearly 300 sail of colliers in the Pool.

The improvement of the navigation of the Thames appears to have been begun at a very early period; for the greatest part of the embankment that reaches from the Nore almost as high as Richmond (a work, by the bye, the importance or even existence of which appears to be little known) is so ancient, that there is not any record or trace in history when or by whom it was formed. Southwark is expressly mentioned in the year 1102; yet as it stands on ground evidently protected from the river by an embankment, the Thames must have been embanked before that period; and there is even good reason to believe, that the embankment was formed as early as the time of the Romans, as they had houses and burying-grounds in St. George's Fields; ground undoubtedly below the level of the high tides. The site of St. John, Wapping, and parts adjacent, were anciently within the influx of the river, and are supposed to have been first embanked in the year 1544. In the years 1513 and 1544, forts were built for guarding the river and protecting its navigation. In 1606 and 1624, acts of parliament were passed for the improvement of its navigation as high as Oxford. In 1636, a commission was issued for inquiring into and preventing encroachments on the river Thames by ladders, stairs, trap doors, &c. from which rubbish and dirt were usually thrown into it, to the great detriment of its navigation. In 1685, it was ascertained that between that time and the year 1649 the river had lost nearly 4 feet in depth. In the year 1776, at the commencement of the American war, the punishment of transportation to America was changed to that of hard labour in raising sand, soil, and gravel, from the shoals in the Thames; and the next year, the corporation of the city of London (whose conservancy of the river extends as high as Stains bridge) finding their operations in improving the navigation above London impeded by the interference of private proprietors of tolls, obtained authority from parliament to purchase all the private tolls, and to take a moderate toll from every barge, in proportion to tonnage and distance. Such are the principal measures that have been adopted to preserve and improve the navigation of the Thames. At present, the banks, &c. that are occasionally formed by the current, are removed either by manual labour, or by means of the dredging machines.

The warehouses and docks next require our notice. Nearly the whole of the north side of the Thames, and a great portion of the south side, from Westminster Bridge to Poplar, and the opposite shore, is occupied by wharfs and warehouses. The East India Company's warehouses are also very extensive: they are situated in New Street, Bishopsgate Street, are of very great height, and are fitted up in the most convenient manner. The wharfs having been found very inadequate to the increased commerce of London, various docks have been, within a few years, excavated, to receive the different branches of the trade; and they are justly deemed the most wonderful works of the kind in the world. The first commenced was a navigable canal through the Isle of Dogs, and, on the north side of the canal, docks, wharfs, and magazines for the West India trade: they were begun in 1800, and completed in 1802. The river here forms a great bend, round a low head of land, called the Isle of Dogs, through which the canal and several basins have been dug, covering about 60 acres, and kept always full by means of locks; so that the largest ships may be always afloat. These basins are divided into basins of imports and exports, and surrounded by ranges of warehouses to a prodigious extent. The northern dock, for imports, is 2600 by 510 feet, and 29 feet deep: it will hold between 200 and 300 sail of ships. The export dock on the south side is 2600 by 400 feet: the depth of both is 29 feet. An open shed, along the whole line of the water in front of the warehouses, receives the cargoes: the goods are hoisted up to the warehouses by means of cranes with chains. Some idea of the great facilities afforded to commerce by the docks may be formed, when it is stated, that, in the course of five months, 460 vessels have been discharged, their cargoes consisting of 160,000 hogsheads of sugar, 32,000 casks and 125,000 bags of coffee, 11,000 bales of cotton, besides a quantity of pimento, cocoa, and wine. The East India docks are situated a little below Blackwall: they were built in 1805. The discharging dock is 1410 feet long and 560 wide, containing 18½ acres. The loading dock is 780 feet long and 520 wide, containing 9¼ acres: the depth of both is 30 feet. They are entered from the river by a basin of 2¾ acres: the entrance lock is 210 feet long, and the gates 48 feet wide: the depth in ordinary spring tides, is 24 feet. The London dock, which was built in 1803, is erected in the angle of the river below Wapping, between Ratcliffe Highway and the Thames: it covers 20 acres. Its length is 1262 feet, and width 690; its depth 27 feet. It is capable of receiving 230 vessels of 300 tons and upwards. The warehouses for storing tobacco and wine cover 5 acres, and the whole is surrounded by a wall.

The trade between London and the other parts of Great Britain, is carried on partly by means of coasting vessels and barges, which navigate the Thames and the canals, &c. connected with it, and partly by means of waggons, &c. The former branch has been already considered: with regard to the latter, it is calculated that above 40,000 waggons and other carriages, including their repeated journies, arrive and depart annually, laden with goods of various descriptions, occasioning a transit of probably 50,000,000*l.*; this, with about 70 millions of foreign and coasting trade, will make together a sum of about 120 millions worth of property annually moving to or from London. The Thames unites with the Grand Junction Canal at Brentford; but London derives a further advantage from this canal, by its being carried into its immediate vicinity at Paddington; and by means of it, a great and increasing communication is carried on between the metropolis and nearly the whole of England. It is intended to extend this canal, till it joins the Thames at Wapping.

The manufactures of London are very various, and some of them are carried on on a very extensive scale. The southern banks of the river, for a considerable extent, are lined with manufactories, such as iron-founders, dyers, soap and oil-makers, glass-makers, distillers, and hat-makers, &c. The other principal manufactures consist chiefly of fine goods and articles of elegant use, such as cutlery, jewellery, articles of gold and silver, japan ware, cut-glass, cabinet-work, carriages, &c. The breweries, ship-building-yards, oil-cloth and paper-hanging manufactories, vinegar works, and chemical manufactories, also, are on a large scale; but the manufactures that employ the greatest number of men, are the silk manufactures in Spitalfields, and the watch manufactory in Clerkenwell, each of which employ, when trade is brisk, about 7000 people.

The retail trade is immense. This will clearly appear, when we reflect that the population of London exceeds one million; that the strangers who are constantly in the metropolis are very numerous, and are always purchasers to a very large amount; and that there are two sets of streets running almost parallel nearly the whole extent of London from east to west, which, with very few exceptions, form a line of shops; the one lying to the south, near the river, extends from Mile-end to Parliament Street, more than three miles in length, including Whitechapel, Leadenhall Street, Cornhill, Cheapside, St. Paul's Churchyard, Ludgate Street, Fleet Street, the Strand, and Charing Cross. The northern line, which extends about four miles, reaches from Shoreditch Church almost to the end of Oxford Street, including Bishopsgate Street, Threadneedle Street, Cheapside, which is common to both sides, Newgate Street, Snowhill, Holborn, Broad Street, St. Giles, and Oxford Street. There are, besides, other streets, not in either of these lines, which contain almost entirely large shops; such as Fenchurch Street, and Gracechurch Street, in the city, and Cockspur Street, Pall Mall, St. James' Street, the Haymarket, Piccadilly, Bond Street, &c. at the west end of the town.

To complete our account of the commerce of the metropolis, it will be necessary to notice the public buildings which are connected with it.

At the head of these must be placed the Bank of England. It was begun to be built in 1732; and in 1734, the centre, court-yard, hall, and bullion court, were finished. In 1770, the eastern wing was added; and in 1804, the western wing, with the front towards Lothbury. The architecture of the Bank of England is heavy and inelegant; but its interior is arranged and fitted up with every regard to the convenient and regular transaction of business. The principal entrance is from Threadneedle Street. On the east side of this entrance is the Rotunda, where business in the public funds is transacted by the stock-brokers, &c. The various offices for the management of cash, particularly stock, are arranged near the Rotunda. Besides these, the hall in which bank notes are issued and exchanged, the bullion court, and the place in which bank notes are burnt, are well worth visiting. The number of clerks employed is 1100: the hours of business are from nine in the morning to five in the afternoon, holidays excepted. Any person may pass through the Rotunda and most of the other apartments.

The exchange was built by Sir Thomas Gresham, at his own expence, in 1567; but this building having been destroyed by the fire of 1666, the present building of Portland stone was erected. There are two fronts; one in Cornhill, and the other in Threadneedle street; each of which has a piazza: between these fronts is an area, 144 feet by 117, in which the merchants assemble; the time of high change is from three to five o'clock. In the upper story of the wall of the quadrangles, are the statues of the Kings and Queens of England, from Edward I. The whole extent of the Royal Exchange is 203 feet by 171. The upper rooms are occupied by Lloyd's Coffee house, a celebrated place of meeting for underwriters and insurance brokers; the Royal Exchange assurance office, &c.

The present post office, which was built in 1660, is most inconveniently situated behind Lombard street; it occupies an area of 27 800 feet, and cost 200,000*l*. It is calculated, that 20.000 persons resort to the post office in the course of a day, and that the inland correspondence to and from London brings in nearly one half of the Post Office revenue, or about one million annually. These considerations, added to the want of room and convenience at the present Post Office, have led to the resolution of building a new Post Office in St. Martin le Grand; the operations have already begun; the area is to extend over the space of 69,000 feet. There are houses with boxes for receiving letters in almost every street; the two-penny Post Offices, for the receipt and delivery of letters in and near London, has two principal offices, at the General Post Office, and in Gerard Street; there are, besides, numerous recording offices: this Post Office comprehends in its deliveries a space of about 10 miles round the metropolis.

The Custom House was first established in the 6th year of Richard II. Being burnt in 1718, it was soon afterwards rebuilt; and having been again burnt in the year 1814, it was again built on a much more extended scale, and in a much more convenient manner. It is situated in Lower Thames Street, a little below Billingsgate: the area comprises 52,500 superficial feet: it is 480 feet long, 100 feet wide. The long room is 190 feet by 67, and is well worth examining, not merely on account of its great length, but also on account of the manner in which it is constructed and fitted up. The front of the building next the river is very handsome; the whole will accommodate 1700 clerks, tide-waiters, &c. The lower floor consists of bondage vaults. The Excise Office is situated in Broad street; it is rather a handsome building: there is also another building for this branch of the revenue on Tower Hill. The Trinity House and New Mint are also situated on Tower Hill: the former is a handsome structure. The duty of the corporation of the Trinity House, is to superintend the interests of the British shipping; and, as more immediately connected with London, to superintend the deepening and cleaning of the river, to appoint pilots for it, &c. The Mint was formerly within the Tower; but within these few years it has been removed to an elegant building, erected on purpose, on the north east corner of Tower Hill. Its area comprises 159,700 feet, of which 71,200 are in the building: it cost 228,656*l*. exclusive of machinery. The steam engines, &c. for coining, are on the best principle, and well worthy of examination. The Auction Mart, opposite the Bank of England, the Corn Exchange, in Mark Lane, and the Coal Exchange in Thames Street, merely require mention, as buildings connected with the trade of London. The East India House in Leadenhall Street, deserves more notice in this point of view. It was originally built in the year 1726, but it has been lately very much enlarged and beautified: the interior contains a great many eastern curiosities, particularly the monuments of Hindoo antiquities and superstition, the spoils of Tippoo Sultan, &c.

We have thus noticed and described the principal public buildings in the metropolis, in connection with an account of the purposes for which they were erected. The only building of consequence, which could not be thus noticed, is the Monument. It is situated about 200 yards to the north of London Bridge, and was built by Sir Christopher Wren, in memory of the great fire in 1666, which broke out near this spot. From its situation it cannot be seen to advantage, otherwise it would be more generally acknowledged to be a very fine pillar. It is of the Doric order, fluted: its total height is 202 feet, the exact distance of it from the spot where the fire first broke out; the height of the column itself is 120 feet, and the cone at the top, with its urn, is 42 feet; the height of the pedestal is 40 feet; it is 15 feet in diameter at the base. It is ascended within by a flight of 345 steps: from the balcony the view is very extensive and grand, both of London and the contiguous country.

The population of the metropolis may be considered in three points of view. In the first place, its amount and increase at various periods, taking London as a whole, in its most usual and extended occupation of the term; *Secondly*, the positive and relative increase or diminution of the various parts of which London is composed; and, lastly, the comparative population of London and the kingdom at large, at different periods. First, with respect to the population of London at different periods: We shall not begin earlier than the great fire of 1666. At that time, there were 66,000 houses in London: in the year 1686, the number of houses in London had increased from 66,000 to 88,000; and the number of inhabitants from 500,000 to 695,000. It will be remarked, that at both these periods, there were nearly eight inhabitants to a house. It is also worthy of remark, that if we go back to the time which preceded the cessation of the plague in London, we shall find, that during the existence of this scourge, the increase of the population of London had been more considerable in proportion, than during the 20 years which followed it; the numbers having doubled at every period of 40 years: there were 77,000 in the year 1565, and 669,930 in 1682. The population of the rest of the kingdom did not increase nearly so rapidly; for the population of England, which in the year 1565 was 5,526,900, only reached 7,360,000 in 1682: London, at the latter period, formed the eleventh part of the whole.

In the year 1781, an enumeration of the chargeable inhabited houses in London was made up at the tax office, of which the following is an abstract.

London city	16,332
Westminster and liberty	17,013
Mary-le-Bone	3,664
Chelsea	610
Kensington	700
Pancras	1,273
Islington	828
Hackney	1,168
Southwark	12,120
Deptford	926
Greenwich	1,555
Total	56,189

In the year 1801, it appeared by the returns to Parliament respecting the population of Great Britain, that London, taken in its usual and most extended signification, contained 900,000 inhabitants. The following is an abstract of the population return for the year 1811 :

Adjoining Streets, or on the Stones.

The city of London within and without the ancient walls	120,909
The city of Westminster	162,085
Southwark (4 parishes)	51,835
St. Andrew's, Holborn, and liberties	31,454
St. Giles	34,672
St. Mary-le-Bone	75,624
St. George's, Bloomsbury	13,864
Pancras, (two-thirds on the stones)	30,889
Clerkenwell	30,537
Spitalfields and Bethnal Green	46,737
St. Luke's, Old Street	32,545
Shoreditch	43,930
Whitechapel	27,578
St. George's in the East	26,917
Shadwell	9,855
Christchurch, Surry	11,050
Lambeth	41,644
Newington Butts	23,854
Bermondsey	19,530
Limehouse	7,387
Horsley Down	8,370
Rotherhithe	12,114
Tower Rolls, Artillery-ground, and other small districts and liberties	28,576
Total in adjoining houses and streets	897,946

In Villages either actually adjoining, or closely connected with London.

Islington	15,065
Hackney	16,771
Stepney	35,199
Stratford-le-Bow	2,259
Paddington	4,609
Chelsea	18,262
Kensington	10,886
Pancras (one third) Kentish Town	15,444
Stoke Newington	2,149
Camberwell	11,309
Clapham	5,083
Deptford	19,833
Greenwich	16,947
Total in the adjoining villages	173,716
In adjoining streets	897,946
	1,071,662

It is calculated that the total population of all the parishes, whose churches are within a circle of eight miles round St. Paul's, is 1,220.000.

The following Table does not comprehend Southwark, the out parishes in Middlesex and Surrey, nor those parishes not included within the bills of mortality :—

	London within the Walls.	*London Without.*	*Westminster.*
Houses inhabited	8158	9,255	17,555
Families inhabiting them	11,649	15,448	38,160
Houses building	22	39	67
Houses uninhabited	269	189	547
Families employed in agriculture	4	9	163
In trade	9779	11,790	22,679
All others	1886	3,649	15,318
Males	27,566	31,667	74,538
Females	27,918	33,748	87,547
Total	55,484	65,425	162,085

Taking the area of all the parishes usually included in London at about 30 square statute miles, or 19.200 statute acres, the number of inhabitants in each square mile, or 640 acres, will be 33,651.

Secondly, with respect to the positive and relative increase or diminution of the population of the various parts of which London is composed, the following Table will afford an accurate and clear idea. It may be proper, however, to premise that a 25th part is added to the enumerated population for the sailors, &c. supposed constantly to be on board the ships lying in the river.

	1700	1750	1801.	1811.
London within the walls	139,300	87,000	78,000	57,700
Without the walls	69,000	57,300	56,300	68,000
Westminster	130,000	152,000	165,000	168,600
Out parishes within the bills of mortality	326,900	357,600	477,700	593,700
Parishes not within the bills of mortality	9,150	22,350	123,000	162,000
Total	674,350	676,250	900,000	1,050,000

Hence it appears, in the first place, that the population of the ancient city, or that included within the walls, in an area of 1½ mile long from east to west, and rather more than ½ mile in breadth, was three-fifths less in the year 1811 than it had been in the year 1700. This diminution is easily accounted for. It arises principally from a great number of houses which were inhabited in 1700, being now used only as warehouses; and it will be observed, that this and the other causes of diminution of inhabitants in this part of London, are continually augmenting in operation. Secondly, from this Table, it appears that, in the years 1750 and 1801, the population of London without the walls was less than it had been in 1700. This probably arose from the cause already specified; but it is not easy to account for the population of this part of the metropolis having, in 1811, again nearly reached the amount at which it stood in 1700. Lastly, the increase of the population of the out-parishes, not in the bills of mortality, is in a much greater rate than that of either Westminster or the parishes within the bills. This may be chiefly ascribed to the immense increase that has taken place in the parish of Mary-le-Bone; and to the large increase that has also taken place in Chelsea, &c. It may be proper to remark, that the discrepancy between the total result of the population of London in the above Table, and that which appeared in a former table, arises from the parishes of Deptford and Greenwich not being in the Table just given, while, on the other hand, in the former table, no addition was made for the shipping population.

Lastly, with respect to the increase in the population of the metropolis, compared with the increase in that of the kingdom at large, at different periods, it has been already found, that, from the middle of the 16th century, to about the end of the 17th, the population of London increased at a much greater rate than that of the kingdom at large, since London increased from 77,000 in 1565, to 669,930 in 1682; whereas the whole of England, including London, increased, during that period, only from 5,526,900 to 7,360,000. In the year 1682, London formed an eleventh part of the whole. It ought to be observed, however, that there is good reason to believe that this statement of the population of England in 1682, which is given by Sir William Petty, is much overcharged, and it by no means agrees with the statement of the population of the kingdom in the year 1700, as given in the population abstract of 1811. In comparing, therefore, the population of the metropolis and of the kingdom at large, we shall take our estimate from the population abstract:—

	1700	1750	1801	1811
England	5,475,000	6,467,000	9,343,578	10,791,107
London	674,350	676,250	900,000	1,050,000

Hence it appears that the population of London has not increased so rapidly as the population of the kingdom at large: for, in the year 1700, it contained nearly $\frac{1}{8}$th; in the year 1750, rather above $\frac{1}{10}$th; and in the years 1801 and 1811, rather less than $\frac{1}{10}$th. The population of England, during the period between 1801 and 1811, increased 14$\frac{1}{2}$ per cent.: The population of Wales, 13 per cent.; and the population of London between 12 and 13 per cent.

The following Table exhibits the number of baptisms, burials, and marriages, in the year 1810:—

	BAPTISMS.			BURIALS.			MARRIAGES.
	Males.	*Females.*	*Total.*	*Males.*	*Females.*	*Total.*	
London within the walls	557	587	1164	710	618	1328	1139
Without the walls .	1399	1421	2820	1013	990	2003	1113
Westminster . . .	2370	2199	4569	2632	2412	5044	2939
Out parishes in Middlesex and Surrey .	6386	6349	12,734	6224	6348	12,572	5195
Parishes not in the bills of mortality . .	1711	1662	3372	1845	1856	3701	1339

Annual average number of unentered baptisms, from 1801 to 1810, 1845; burials, 5753; marriages 27.

London is remarkably healthy, considering the denseness of the population, the narrowness of many of the streets, and the poverty and filth of a large portion of its inhabitants. Its salubrity arises from several causes. In the first place, the soil on which it stands is either a dry gravel, or a loam of considerable depth lying on the same gravel. Secondly, a large part of it stands on rising ground; and that part which lies comparatively low most thoroughly ventilated by the current of air caused four times in every 24 hours by the tides of the Thames. Thirdly, the full and never failing supply of excellent water, both hard and soft. And lastly, the almost innumerable sewers by which the superabundant moisture and the filth, &c. are carried off, and the great care that is taken to keep the streets free from the surface filth. The climate of London is colder in winter and the early part of spring than might be anticipated from its latitude; while, in summer, it is frequently much hotter. The mean annual temperature from 1702 to 1780 was 51.9; and, during the four last years of the last century, 49.6. The mean temperature of the six winter months, from October to March, is 43.5; from November to March, 42.6; from January to March, 37.9; during February and March, 41.5; from October to December, 47.0; and from December to February, 39.7. The temperature of May, on an average of eight years, is 56.61; of June, 63.22; July, 66.3; August, 65.85; and September, 59.63. The greatest usual cold is 20.0, and occurs in January. The greatest usual heat is 81.0, and occurs generally in July. The limits of the annual variation are 2.5; that is, 1.0 above, and 1.5 below the mean. During the excessive hot weather in July, 1808, the thermometer in the shade stood above 90.0; and it reached the same height during the excessive heat this year (1818.)

During the four last years of the last century, the annual average depth of rain at London was 19 inches; in 1802, 15.12 inches; and in 1806, 27 inches. Compared with the rest of England, there is less rain falls in London than in any other part, with the exception of Norfolk, and some other of the eastern counties. There are about 209 days in the year without rain, and 156 in which it rains and snows. One of the most remarkable circumstances connected with the meteorology of London, is the very dense fogs to which it is exposed generally during the months of November and December; and very serious accidents and inconvenience have often arisen from these fogs. It is ascertained, however, that they extend but a little way beyond the metropolis.

From accurate experiments made by order of the Royal Society, it appears that the south-west wind blows 112 days; the south-east 32; the north-east 58; the east 26; the north-west 50; the south 18; the west 53; and the north 16. The south-west particularly prevails in July and August; the north-east in January, March, April, May, and June: it is often very piercing even to the middle of June. This wind is least common in February, (which is often a very mild month,) July, September, and December. The north-west wind occurs most frequently from November, to March, and less in September and October than in any other months.

The mean height of the barometer in London, upon an average of two observations in every day in the year, kept at the house of the Royal Society for many years, was found to be 29,88; during the four last years of the last century, the average was 29,9.

The mortality in London has considerably diminished since 1700. In that year it was one in 25: in the year 1750, one in 21; in the year 1801, one in 35; and since that period, it has been about one in 38. In the year 1650, the total number of deaths was 8764; in 1700, 19,443; in 1750, 23,727; in 1798 and 1799, 18,000 in each year; in 1800, 23,068; in 1806, 17,938; in 1813, 17,322; and in 1817, there were buried 19,968, of which 10,033 were males, and 9935 females; being a decrease in the burials, compared with 1816, of 348. There were christened in 1817, 24,129, of which 12,624 were males, and 11,505 females. In this year, there died, under 2 years, 5698; between 2 and 5, 2019; between 5 and 10, 929; between 10 and 20, 706; between 20 and 30, 1364; between 30 and 40, 1795; between 40 and 50, 1983; between 50 and 60, 1788; between 60 and 70, 1614; between 70 and 80, 1224; between 80 and 90, 683; between 90 and 100, 156; of the age of 100, 7; and of the age of 105, 2. The following Table exhibits the mortality occasioned, during this year, by some of the most prevalent diseases in London.

Apoplexy and suddenly	462
Asthma	743
Childbed	252
Consumption	4200
Convulsions	3242
Fevers of all kinds	1299
Inflammation	1002
Dropsy	718
Lunatics	245
Measles	725
Mortification	304
Palsy	162
Small pox	1051
Teething	449

The number of those deaths which are included un-the head of casualties, (which comprehends suicides and those executed) amounted, in 1817, to 367, of which about one-third, or 119, were drowned.

The state of the population of England unfortunately is such, that one of the most prominent and obtrusive parts of it is the poor; and this remark applies in an especial manner to London. Very lately, the attention of the legislature has been called to the enormous increase in the poor's rates, and the number of poor supported by them. During the session of parliament of 1818, a very copious report on this subject was laid before it; from which we have extracted the following important and interesting details.

1. Money raised, by poor or other rates:

Easter 1813	L641,832	14	2¼
—— 1814	703,087	1	6¼
25th March 1815	692,934	9	0

2. Money expended for maintenance of the poor.

Easter 1813	L517,181	10	11½
—— 1814	559,695	16	1¼
25th March 1815	521,418	1	5¾

3. Expenditure in suits, removals, overseers, &c.

Easter 1813	L20,066	19	9½
—— 1814	22,153	15	10
25th March 1815	21,785	3	6¾

4. Expenditure for militia purposes.

	Maintenance of families of militia.			Other incidental charges.		
Easter 1813	L16,306	17	11½	L1490	8	10½
—— 1814	17,941	7	7½	595	5	10¼
25th March 1815	9,554	17	9½	558	12	5

5. Expenditure for church rate, county rate, highway rate, &c.

Easter 1813	L139,622	7	3½
—— 1814	159,723	3	11
25th March 1815	154,978	0	0¼

6. Total expenditure.

Easter 1813	L694,668	4	10½
—— 1814	760,109	9	4
25th March 1815	708,194	15	4¼

7. Number of persons relieved from the poor rate permanently, not including the children of such persons.

	Out of any workhouse.	In a workhouse.
Easter 1813	17,354	18,259
—— 1814	18,401	18,174
25th March 1815	18,464	17,452

8. Number relieved occasionally in and out, being parishioners.

Easter 1813	75,310
—— 1814	84,229
25th March 1815	84,309

9. Average number for three years relieved permanently, in and out of workhouses	39,034
Relieved occasionally, being parishioners	81,282
Total	117,316

10. In the year 1803, there were only 59,064 relieved; or about one half of the average number of 1813, 14, and 15.

11. One hundred and forty-two parishes maintain all or part of their poor in workhouses; averaging, for three years, 17,961.

12. In the year 1811, the number relieved by the poor rates was nearly 11 ⅔ in each hundred of the resident population. In the year 1801, the population being 864,845, the number of parishioners relieved was nearly 7⅓ in each hundred. Hence the population has increased 144,701, or nearly one-sixth; and the parishioners relieved have increased from 7⅓ to 11⅔ in each hundred.

13. The money raised for three years, ending 25th March 1815, by poor rates, or other parochial rates, averages 679,284*l.* or 13s. 5½d. per head on the population, or, 2s. 5d. in the pound of the sum of 5,603,057*l.* assessed to the property tax. In 1803, the money raised by poor and other parochial rates was 471,938*l.* at the rate of 10s. 11¼d. per head. Hence it appears, that, on the average of 1813, 1814, and 1815, compared with 1803, there was an increase of nearly one-half on the money raised; and of 2s. 6¼d. on the rate per head.

14. The average of three years of money expended on the poor was 532,765*l.* or 4*l.* 10*s.* 10*d.* for each pauper.

Money, in suits, removals, &c.	L21,335, or $\frac{1}{31}$ of money raised.
—— for militia purposes	15,449, or $\frac{1}{44}$.
—— for all other purposes	151,441, or ¼.
Total expenditure independent of maintenance of the poor	188,225, or, ⅓ of money raised.

15. The money expended in suits, removals, &c. in the year 1803, was 16,786*l.* and the total expenditure, independent of the poor, 130,843*l.* Hence it appears that the former has increased one-fourth; and the latter nearly one-third.

16. Total number of members of friendly societies, parishioners or not.

Easter 1813	54,566
—— 1814	54,555
25th March 1815	69,932

The average number in friendly socities during these years, was nearly 5 in each 100; a decrease, compared with 1803, of nearly 3½ in each 100.

17. Average amount of charitable donations.

For parish schools	*L*5873	4	8
For other purposes.	17,058	17	4¼

It is calculated that there are upwards of 15,000 beggars in London, of which 7000 are children, and 5300 Irish.

There is scarcely any circumstance more astonishing, connected with London, than its constant and regular supply of all kinds of provisions. Without any directing or superintending mind, without any impulse but that of self-interest, upwards of one million of inhabitants crowded within 30 square statute miles, find all their wants supplied. With respect to the quantity of the different kinds of provision annually consumed in London, there can be little more than conjecture, or approximation to the truth; and in this view only we offer what follows.

1. *Bread.*—The quality of the bread in general is very good. The number of bakers is about 1800; and the average weekly consumption of flour about 15,000 sacks. The flour bought by the London bakers in the year 1798, amounted to 778,985, making a weekly average of 13,768 sacks; the quantity bought in the year 1814, amounted to 821,607 sacks, making a weekly average of 15,502 sacks. Mark Lane is the market for corn and flour.

2. *Butcher meat.*—The number of bullocks consumed during 1817 was 164,000, their average weight being about 800 lbs.; of calves 250,000, averaging 140 lbs.; of sheep and lambs 1,620,700; and of pigs 200,000, averaging 60 lbs. The great market for live cattle is Smithfield, where it is calculated that the total value sold annually amounts to about 8,000,000*l*. Leadenhall, Newgate, Whitechaple, Newport, and Clare, are the chief markets for butcher meat.

3. *Fish.*—The quantity of fish consumed is comparatively small, as, with the exception of salmon occasionally, and mackerel during the height of the season, it is extremely dear. It is calculated that about 120,000 tons are annually brought to Billingsgate, the only wholesale market for fish in London; of which quantity 100,000 tons are brought by sea, and 20,000 tons by land.

4. *Poultry*, &c.—Poultry is in general still dearer than fish, and the consumption, therefore, is comparatively very small. The same remark may be made with respect to game and vension.

5. *Vegetables and fruit.*—The former are of excellent quality, but seldom very cheap; the latter are both good and cheap. The supply of the former is chiefly drawn from the 10,000 acres cultivated near London with vegetables; and the fruit from the produce of about 30,000 acres. Covent Garden and Spitalfields are the principal markets for vegetables and fruit. The display of these and of flowers (during the season) in the former, early in the morning of the market-days, (Tuesday, Thursday, and Saturday,) is very striking.

6. *Water.*—London, as has been already remarked, is most abundantly supplied with water, both hard and soft. The former is obtained in every part of the city at no great depth, and is in general of excellent quality. The latter is derived from the pipes of the different water companies, of which the principal are the New River Company, which supplies 214,000 hogsheads every 24 hours; the London Bridge water works; the Chelsea water works; the York Buildings water works; the East London; the South London; the West Middlesex; and the Grand Junction works.

7. *Milk.*—It is calculated that nearly 9000 cows are kept to supply the metropolis with milk; one man alone keeping 999 cows; and that the total annual consumption is nearly 7 million gallons. The quality is very indifferent, and the price very high.

8. *Ale, porter, spirits*, &c.—The quantity of ale, porter, and spirits consumed is enormous. The labouring classes in general work hard, and they believe that they could not support themselves, unless they drank a great deal of strong liquor. It is calculated that upwards of 70 millions of gallons of ale and porter, and 11 millions of gallons of spirituous liquors, are annually consumed, besides wine. The annual consumption of coals is about 800,000 chaldrons; of butter, upwards of 20 millions of pounds; and of cheese, nearly the same quantity.

When the immense population of the metropolis is considered, as well as the various circumstances in which the different parts of it are placed, and the various sources from which they are drawn, it must be obvious, that it is impossible to give their character with any considerable degree of precision or justice. It has been remarked, however, (and the remark is not so fanciful and ill-founded as might be supposed, by those whose observation has not been very attentive and of long standing,) that in London there are three grand and very distinctive classes of persons, and that each of these may be seen in succession, as we pass from the west end of the town to the extremity of the shipping part of the metropolis. In the west end of the town, there is obviously more polish of manners, but less quickness and bustle, than in the city, commonly so called; while, in the city, there is more polish than in the shipping portion of London. It is in the city, however, that the most genuine part of the London character may be traced. The very children of the Cockneys, (as they are called) or of those who have been born and educated in London, and have either never quitted it, except for an annual excursion to Margate, &c. or on business, and, in the latter case, without any preparatory knowledge for their journey, and with their thoughts entirely occupied by their business while absent from home; the children of these people are distinguished by a smartness and pertness of manner, at a very early age, and by a quickness of intellect, which seems to promise active and intelligent manhood, though this promise is very seldom fulfilled. Nothing strikes a stranger, in passing through the streets of the city, so much as the quick and eager manner in which the immense crowds that constantly fill them press forward. Time is evidently precious with them, and business as evidently completely occupies their thoughts; and undoubtedly two of the most distinguishing features of the inhabitants of London, in every part of the metropolis, are the attention, and eagerness, and application, with which they pursue business, during the hours and days devoted to it, and the equal eagerness with which they seek out and enjoy relaxation and amusement at those times when they can no longer attend to business. This probably is one great cause of the want of information, with which the inhabitants of the metropolis, in general, are too justly charged. Their sons receive a short and superficial education, the effects of which are almost entirely obliterated in a very few years, by their parents forcing them into business at a very early age; and, while in business, it and amusement occupy the whole of their time and thoughts.

Such may be deemed the unfavourable side of the picture: the favourable side presents us, in London, with an immense mass of worth, talent, and intelligence; but, from the extent of the metropolis, and from the prevalent custom of rather abstaining from that intercourse of neighbourhood which is so usual in all other towns, the portions of this mass are extremely scattered, and are difficult of access, even to one well acquainted with the metropolis, and who is favoured with the best introductions.

The signs of the wealth of the inhabitants are very conspicuous in almost every part of London. In the west end, the immense number of splendid carriages, and the equally astonishing number of large and excellent houses, that adorn and distinguish not only the squares and the streets immediately connected with them, but almost the whole of the new district to the north and north-west of Oxford-street, sufficiently prove that there must be a vast number of very wealthy inhabitants. The signs of wealth in the city are rather of a different character, but they are equally conspicuous and certain. The almost uninterrupted lines of wagons, carts, &c. which from morning to night crowd the streets in both directions; the numerous and well furnished shops; and the carriages, which, though not so splendid, are almost as numerous as in the west end, are sure indications and consequences of this wealth. In the shipping part of the metropolis, the more splendid and imposing signs disappear; but there remains the immense number of wagons, and there is superadded the ships, warehouses, wharfs, and docks.

It may be remarked, that some of the most characteristic features of the English nation are to be seen in a most prominent and conspicuous manner in London. This observation especially applies to that fondness for good eating, (to use a homely but expressive term,) with which the English nation are charged. In London this fondness is carried to an extreme, and finds its way down to the lowest classes of society. They work hard, in general earn high wages by severe labour, and then spend the greatest part of their earnings in eating and drinking. The clear gains made by some of the gin shops in the city, and near the shipping, have been ascertained to amount to upwards of 2000*l*. a year.

In the preceding sketch, we have only drawn some of the most characteristic features of the inhabitants of London, and such as apply principally to those whose characters have been formed by the mode of life, manners, habits, and pursuits of the metropolis. As we have already remarked, there is no one feature which distinguishes so great a portion of them so much as their fondness for amusement after business is over; and the principal of these amusements and modes of relaxation we shall now notice.

1. *The Theatres.*—It has frequently been remarked, with an expression of surprise, that the theatres in London are very few, compared with the population, or with the number in Paris; but this remark is not well founded in either respect; for if we reflect on the immense size of the two great theatres, Drury Lane and Covent Garden, and that, besides, there are the Opera House, the Haymarket, the Lyceum or English Opera House, the Surrey theatre, the Cobourg theatre, a theatre in Goodman's Fields, Astley's amphitheatre, and Sadler's Wells, besides one or two other places of similar amusement, on a smaller scale, we shall be disposed to admit that London is not deficient in theatres, (taking the town in an extended sense,) either when we regard its population, or compare it with Paris in this respect. Drury Lane was rebuilt in the year 1811, having been burnt down in 1809. The outside appearance does not strike the beholder much; and even if it were more beautiful or magnificent, the narrowness of the street in which the principal front is placed would prevent its being seen to advantage; but the elegance and splendour, and, in some respects, the grandeur of the interior, compensates for the plainness of the exterior. It is of immense size, too large indeed for the representations to be well seen or heard in all parts of the house. It is calculated that 2810 persons may have sitting room in the different parts of it, viz. 1200 in the boxes, of which there are three complete circles, each containing 26 separate boxes; 850 in the pit; 480 in the lower gallery, and 280 in the upper gallery. The body of the theatre is so formed as to present nearly three-fourths of a circle from the stage. From the hall of entrance there is a passage to the rotunda, which is uncommonly elegant. But the most striking part of the interior of the building, not connected with the representation, is the saloon. It is 86 feet long, and circular at each extremity: at the ends of the saloon are convenient rooms for coffee and other refreshments. The Drury Lane company commence their performances in September, and terminate them in July.

Covent Garden theatre was rebuilt in 1809, having been burnt down the previous year. The principal front in Bow-street is adorned by some very classic sculptures by Flaxman, and has, on the whole, a very striking appearance. The interior is equally elegant as that of Drury Lane, and the size very nearly the same. The pit is almost square, about 50 feet by 50, and will hold conveniently 750. There are 26 lower boxes, which, at 12 persons each, will hold 312; certain back boxes, called the basket, which may hold 180. The 2d, 3d, and 4th rows of boxes will hold at least 600; so that the boxes and pit will probably hold, without inconvenience, about 1800 persons. The galleries will hold about as many as those of Drury Lane. This theatre opens and shuts at the same seasons of the year as Drury Lane.

The Opera House, or King's theatre, in the Haymarket, is entirely for Italian operas and ballets. At present the front is very mean-looking, but it is intended to render it more suitable to the elegance of the interior; and this certainly surpasses the interior, both of Drury Lane and Covent Garden. The stage is 60 feet long, and 40 across from box to box. There are five tiers of boxes, and each box will hold six persons with convenience. They are inclosed with curtains, and furnished with chairs. The pit is 66 feet long, and 65 broad, and contains 21 benches. The gallery is 42 feet deep, and 62 broad, and contains 17 benches. The boxes will hold about 900 persons; the pit about 800; and the gallery nearly the same number. Coffee, tea, fruit, &c. are furnished in the lobbies, which are about 20 feet square. The great concert room is 95 feet long, 46 broad, and 35 high, and is uncommonly elegant. The boxes are private property. The company must go full dressed both to them and the pit. The opera season commences in December, and continues every Tuesday and Saturday till June or July.

The theatre in the Haymarket, or the Little Theatre, as it is called, is a summer theatre. It is inconveniently small for this season of the year, and is not elegant, either externally or internally. There are three tiers of boxes, a pit, and two galleries. By the patent, it cannot begin its performances before the 15th of May, nor extend them beyond the 15th of September.

The English Opera, or Lyceum, in the Strand, is, as the name indicates, confined to the performances of English operas. It is a small but convenient and rather elegant house. Sadler's Wells, near Islington, is chiefly distinguished for its exhibitions on a large sheet of water, which can be made to cover the whole stage. It opens on Easter Monday, and continues during the summer season. Astley's Amphitheatre, near Westminster Bridge, is principally distinguished for its equestrian exhibitions. The exhibitions at the Cobourg Theatre, on the Surrey side of Waterloo Bridge, and the Surrey Theatre in Blackfriar's road, are confined to pantomimes, burlettas, &c.

Such are the principal places of *inn-door* amusement, to which the inhabitants of London resort. Of their places of out-door amusement, Vauxhall is the most celebrated, and, in good seasons, the most frequented. Vauxhall Gardens are situated about half a mile from Westminster Bridge, in South Lambeth, and a few minutes walk from the river. The gardens are very extensive, and laid out with taste; but their great attraction arises from their being splendidly illuminated at night (when they are open to company) with about 15,000 glass lamps. These being tastefully hung among the trees, which line the walks, produce an impression similar to that which is called up on reading some of the stories in the Arabian Nights Entertainments. There is, besides, a large orchestra for instrumental and vocal music, and a very brilliant display of fire works. The gardens open about the middle of May, and close about the middle of August. On some occasions, when the weather has been uncommonly fine, there have been upwards of 12,000 persons in them; and this immense concourse, most of whom are well dressed, seen in connection with the illuminated walks, add not a little to the brilliant and astonishing effect of the whole scene.

The Parks, and Kensington Gardens, the former of which have been very aptly called the lungs of the metropolis, are much resorted to during the Summer and Autumn, especially by those who live at the west end of the town. St. James' Park, when seen from a situation in which its fine groups of trees, its water, and Buckingham House, can be taken into the view together, is a very beautiful object, and appears rather like the well laid out pleasure ground of a nobleman, than a park in the immediate vicinity of the metropolis. But this pleasing and imposing appearance is in a great measure lost when in the park itself. It is too flat and too formal in its walks. The Green Park, which lies between St. James' Park and Piccadilly, is a beautiful spot, both on account of its rising and uneven surface, and from the verdure with which it is generally clothed; but it is without those fine clumps of trees that adorn St. James' Park. At the north-east corner there is a fine piece of water. In the Summer Sunday evenings, the walks in this park are crowded with well dressed people. Hyde Park is very different in appearance, and three times as large as the other two together. It is contiguous to the western extremity of the metropolis, extending in breadth from Piccadilly to Oxford-street. Its principal entrances are from these streets. It is an enclosure of about 400 acres, slightly uneven, with here and there groups of old trees, some of them of very large size and great age. The water of a rivulet dammed up has been made to fill a little valley. It is called the Serpentine River. Its boundaries are concealed by several projecting points of land and corresponding bays. Hyde Park is used for the field days of the horse and foot guards; and is much frequented, especially on the summer Sundays, by carriages and people on horseback. Kensington Gardens are connected with Hyde Park. Their circumference is about 2½ miles, and they contain about 260 acres. They are well laid out; and the views in some parts of them, where the groups of trees can be seen to advantage, are very fine. It has been computed that 50,000 people have been recreating or amusing themselves at one time in Hyde Park and Kensington Gardens. The latter are open only from Spring to Autumn; the parks all the year.

Within these few years a park has been laid out, and partly finished, to the north-west of the parish of Mary-le-Bone. It is called the Regent's Park; and as, according to the plan, there are to be in it, not only spacious rides, shrubberies, and water, but also elegant houses, it cannot fail, when completed, to prove an additional ornament, as well as a great convenience, to this part of London.

The parks and Kensington gardens are resorted to chiefly by the higher and middle classes of Society in London. The lower orders of tradesmen and the labouring classes seek for recreation and amusement, during the summer Sundays, (the favourite time for recreation and amusement for all classes,) at different places. These are principally the tea gardens, with which the vicinity of the metropolis, in every direction, abounds. Excursions are also made by most classes, during the summer Sundays, to some of the villages near London; or to Richmond, Kew, Hampton Court, Windsor, Gravesend, &c. The villages to the north of London, which are most frequented, are Hampstead and Highgate. The former is one of the most beautiful villages near the metropolis, and the views from its heath, especially to the north-west, are uncommonly extensive and rich. The view of London and the Surrey hills from Highgate strongly resembles a beautiful and highly finished picture. To the east of London, Greenwich and Shooters Hill are much frequented. The former, on account of its fine park; and the latter for the view which it affords, in one direction, into the picturesque county of Kent; and, in another direction, over London, and the Thames crowded with shipping. Excursions to Kew, Richmond, and Hampton court, by water, during the summer seasons, are very common. Till lately, these excursions were made in wherrys; but, within these few years, steam boats sail regularly,—and from their decks the banks of the Thames may be more fully and conveniently seen. Those above Battersea Bridge are uncommonly rich and beautiful, and are adorned with a great many tasteful seats. The other aquatic excursions in which the inhabitants of the metropolis are fond of indulging are to Gravesend, to which place small vessels of 30 or 40 tons sail every tide, and carry passengers at very moderate fares. Excursions are also made to Harrow on the Hill, in the passage boats on the Paddington Canal. In short, on a fine summer Sunday, the roads in the vicinity of the metropolis are literally crowded with people on foot, on horseback, and in all manner of vehicles; and as the lower classes generally take all their family with them on these occasions, nearly as many children as grown up people are to be seen. When the immense business carried on in the metropolis is considered in connection with this fondness for recreation, it may well be imagined that an immense number of coaches of all descriptions must be necessary. To most of the villages very near London, such as Islington, Hackney, Kensington, Chelsea, Greenwich, &c. there are stages every half-hour or every hour; and to villages rather more distant, five or six times a-day. There are likewise upwards of 1100 hackney coaches and chariots, besides glass coaches, or coaches that can be hired for the day or journey, gigs, saddle-horses, &c. As the roads round London are level, and at most seasons uncommonly good, the rate of travelling is very rapid, and thus the inhabitants, in the course of a day, can go and return a considerable distance.

The history of London naturally divides itself into two parts: the history of its increase and improvements; and the history of the principal events of which it has been the scene. In treating of each of these we must be very brief.

I. *The history of its increase and improvements.*—London is supposed to have been founded prior to the Roman invasion; but it is first expressly mentioned by Tacitus, A. D. 61. It is supposed to have been surrounded by water in the time of Constantine the Great. In the year 604, Bede calls it "a mart town of many nations, which resorted thither by sea and land." Soon after, Westminster Abbey and St. Paul's church were first built. A timber bridge across the Thames is first mentioned in the year 1016. In 1070, William the Conqueror granted a charter to the city; and the same year the corporation obtained jurisdiction over the river. In the time of Henry II. an immense forest covered the northern division of the city; on the north-east was a large lake, now Moorfields; on the east were the marshes of the Isle of Dogs; and on the west those of St. Peter and Tothill-fields. There were then, and till much later, great gardens between London and Westminster. In this reign, it was first established as the capital; many houses were built of stone, but most of wood, and thatched with straw. In 1176, a bridge of stone was built. In the year 1236, the inhabitants having been deprived of their usual supply of water, in consequence of the buildings extending over Oldbourn, (Holborn,) Wallbrook, and Langbourn, brought it from some springs in the village of Tyburn. In 1255, a conduit in Cheapside was supplied with water by leaden pipes. About this time, the use of coal among dyers, brewers, &c. became common. In 1320, a fish-market was established at Fish Wharf; and in 1340, tolls were established for paving the way in and near the city. In 1410, Stocks market was erected; and in 1416, the streets were first lighted with lanterns. In 1419, Leadenhall was built as a public granary. In 1443, the supply of water being found insufficient, pipes were laid from Paddington. In 1533, the number of butchers in London and its suburbs was reckoned to be 120, each of whom killed nine oxen weekly; which, in 46 weeks, (none being killed in Lent,) amounted to 33,120 yearly. In 1542, a statute was passed for paving some of the streets, from which it appears that the Strand was not yet built into a continued street. The city being, about the year 1580, considerably increased, Queen Elizabeth published a proclamation, forbidding any buildings to be erected on new foundations within three miles of the city gates; and that only one family should inhabit each house. In the year 1563, another proclamation was put forth, commanding that no new buildings should be erected within three miles of London or Westminster; that one dwelling-house should not be converted into more; and that commons, within three miles of London, should not be enclosed. In 1594, the river water was conveyed into the houses by means of an engine erected at Broken Wharf.

In the reign of Queen Elizabeth, we have the first good map of the metropolis; from which it appears that the greater part was contained within the walls, and even in these narrow limits were many gardens, which have been since converted into lanes, courts, and alleys.

The buildings of London were, on the east, bounded by the monastery of St. Catharine's. East Smithfield was open to Tower-hill, and Rosemary Lane was not built.

The Minories were built only on one side, which fronted the city wall; cattle grazed in Goodman's fields; and Whitechapel extended but a little beyond the Bars, and had no houses on the north; for Spitalfields were divided by hedges and rows of trees. Bishopsgate and Norton Falgate were built as far as Shoreditch church; Moorfields were open to Hoxton; and there were several windmills on Finsbury-fields. The village of Holborn joined London, but the backs of the houses opened into gardens and fields; part of Gray's Inn Lane was built; but there were few houses in High Holborn. St. Giles' was a village, not united to London, in the fields near which the Lord Mayor, &c. used to hunt on the 18th of September, when he visited the Water Springs. In the Strand there were only a few houses near Drury Lane; the streets now leading from it being then occupied by noblemen's houses and gardens. Covent Garden, which was then literally a garden, extended to St. Martin's Fields, and these to St. Giles'. The Haymarket had a hedge on one side, and a few bushes on the other. Westminster was a small place on the south and south-west of St. James' Park, Pall Mall, Piccadilly, St. James' Street, and the adjoining streets and squares, not then being in existence. Coaches were introduced, and the Royal Exchange built, in Queen Elizabeth's reign.

In 1613, the New River was brought to Islington; in 1614, Smithfield was paved; and in 1615, flags were laid on the sides of the principal streets for foot passengers. In the beginning of this century, London and the suburbs increased very much. Spitalfields, and about 320 acres to the south-east and south of it, were entirely covered with houses. In 1618, King James issued a proclamation against new buildings; for regulating the heights of houses, &c.; and for removing nuisances in Lincoln's Inn Fields, "situated in a place much planted round about with the dwellings of noblemen and gentlemen of quality;" and in the subsequent year, another proclamation was issued, regulating the thickness of the walls of houses. In 1640, the suburbs increased very much, especially to the west, in the parish of St. Giles' in the fields, and Covent Garden. In 1625, there were but 20 hackney coaches in London; but in 1654, they had increased so much, and became of so much importance, that they were placed under the controul of the court of aldermen. In 1656, another attempt was made to prevent the increase of London; for this purpose, all houses built since 1620, within ten miles, were taxed, and new buildings fined. All houses within these limits were also ordered to be built without butting out into the street. In 1661, a great many streets in St. James' parish were built or finished, particularly St. James' Street, Pall Mall, and Piccadilly; other streets were ordered to be widened; and candles, or lights in lanthorns, were to be hung out by every house fronting the streets, from Michaelmas to Lady Day, from dark till nine in the evening;—a proof of the early hours at this time. The great plague in 1665 will be noticed in the other division of this history. This was followed, in 1666, by the great fire. It broke out on Sunday, the 2d of September, at the house of a baker in Pudding Lane, within ten doors of Thames Street. The houses here were mostly of wood; and a strong easterly wind spread it rapidly all Monday and Tuesday. On the evening of that day, and on Wednesday, it was stopped near the Temple, Holborn Bridge, Pie Corner, Aldersgate, Cripplegate; near the lower end of Coleman Street; at the end of Basinghall Street; at the upper end of Bishopsgate Street and Leadenhall Street, in Cornhill; at the church in Fenchurch Street; in Mincing Lane, Mark Lane, and at the Tower Dock. On Thursday it was wholly extinguished. It destroyed 13,000 houses, and most of the churches and corporation halls. The value of the property destroyed was computed to be little short of 10 millions.

Before the conflagration, the streets were very narrow, the garrets on each side projected very near, and the houses were chiefly of wood, or lath and plaster. But the opportunity was now taken to widen and otherwise improve the streets, and to build the houses more substantially, and upon a more regular plan. Thames Street was raised three feet; conduits were removed, and many middle rows of houses. In consequence of the sites of the immense merchants houses and city halls, with their gardens, being now built over, it is supposed that nearly 4000 more houses were erected after the conflagration, than had been in the city before. In 1670, another act was passed for widening the streets, and for making Fleet Ditch navigable. There was still, however, a prejudice against erecting new houses; for, in 1674, an order in council was published for punishing all such as built houses on new foundations. In 1676, a great part of Southwark having been destroyed by fire, an act was passed for re-building them of brick instead of wood. So late, comparatively, as the year 1678, there were no buildings on the sites where Wellclose Square, the west end of Ratcliffe Highway, Virginia Street, and all the streets on the side of Ratcliffe Highway to Gravel Lane, and thence to Limehouse, now stand. In 1685, Spitalfields and St. Giles' were much increased by the manufacturers who left France in consequence of the revocation of the edict of Nantz; and the same year, the western suburbs increasing, two new parishes were erected, St. Anne's and St. James', both of which were previously part of the parish of St. Martin's in the Fields. In the year 1683, the great increase in the size, population and traffic of London, suggested the establishment of the penny post. In 1689, the Seven Dials were built. In 1694, in consequence of the vast increase of the commerce and shipping of London, the suburbs to the east of the tower were become so extensive and populous, that a new parish was erected by the name of St. John, in Wapping. In 1722, the Chelsea water company was formed, for the better supplying of Westminster and the western suburbs with water. It was between this year and the accession of the house of Hanover, that Hanover Square, Cavendish Square, and the streets adjacent, Bedford Row, Red Lion Square, Hatton Garden, &c. were built. Soho Square was built at the close of the preceding century; and the streets from Leicester Square to St. Martin's Lane, north and west to the Haymarket and Soho, and thence nearly to Knights-bridge, including Golden and Grosvenor Square, were finished in the reign of George I. or early in the reign of George II. In 1730, two new parishes were formed, St. George, Bloomsbury, and St. Anne, Limehouse. About the same time, the north side of Oxford Street was partly built, and many streets near it and Covent Garden were completed.

From the middle of the last century, till within these very few years, the increase of London has been so great and rapid, that it will be necessary to notice it in a summary manner, as our limits will not admit of details; and the increase from 1748 to the end of the year 1810, may be summed up as follows: in the north-east, from Goodman's Field to Stepney, and from Whitechapel Road to Shadwell, with the West India Docks, has been covered with buildings; and from Hackney, to Mile-end and Bethnal Green. On the south-east, from Deptford to Camberwell, Kennington and Stockwell; and thence by Lambeth to Westminster and Blackfriars Bridge, (including these Bridges,) with St. George's Fields; from Hyde Park corner towards Chelsea, (including Sloane Street and the streets adjacent,) and from Chelsea towards Kensington, Hammersmith, &c. On the north, Lisson Green, Camdentown, Somerstown, Pentonville, &c. The increase and improvements have been greatest on the north side; for the large parishes of Paddington and St. Mary-le-Bone have been wholly built: "and the Middlesex and Foundling Hospitals, the paths to which were reckoned dangerous, from the depredations of robbers, are now surrounded with handsome streets:" all the new squares have been erected on the north of the town, as Portman, Manchester, Fitzroy, Bedford, Tavistock, Russel and Brunswick squares, besides Portland Place. Finsbury Square was begun about the year 1779. Before proceeding to notice the increase that has taken place since 1810, it may be proper to advert to the principal improvements that were made between 1748 and 1810: these have been made chiefly since the accession of his present Majesty. About 1760, the city gates were ordered to be taken down. Till the year 1762, the signs, and the gutters for conveying the rain water from the roofs of the houses, projected very much; but this year an act was passed to remove these nuisances, and for affixing the names of the streets on every corner. In 1768, another act was passed for paving, cleaning, and lighting the streets, for regulating the stands of hackney coaches, and for watering the streets when necessary. Mary-le-Bone was not paved or lighted till the year 1770. In 1774, an act was passed for pulling down ruinous houses, for placing fire-cocks in the water pipes, with conspicuous notices of their distance and situation; and for keeping fire engines and fire ladders in every parish. In 1795, an act was passed to enlarge the entrance from the city in Westminster, on the west side of Temple Bar, and to make a straight and broad street from the east end of Tower-hill to the bottom of Holborn.

Since the year 1810, a considerable stop was put to the erection of new buildings, in consequence of the stagnation of commerce, and its being ascertained that a vast number of houses were either unfinished or unoccupied. Latterly, however, London is again beginning to increase, especially on the north side: Montague Square, Bryanston Square, and the streets adjacent, to the north west; and Burton Crescent, and several streets more, to the east; the buildings and improvements in Moorfields, and an immense number of houses in the parishes of Islington, Chelsea, and Kensington, form the chief additions to the size of London within these few years. The principal improvements are in Scotland yard, the formation of the Regent Park, the street leading to it from Carlton House, (now forming,) the lighting of a large portion of London with gas, and the acts regarding the pavement, &c. It may also be remarked, that, in consequence of the numerous Water Companies, water can now be conveyed to the top of the highest houses in the metropolis.

Upon the whole, when we consider the immense size of London, and that by far the greatest part of it was built without any regular plan, we shall be surprised to find in it so much cleanliness, comfort, convenience, elegance, and splendour, as actually exists: it is not like many capitals, that strike at once by the imposing nature of their situation, or by their splendid and magnificent public buildings, seen to the greatest advantage, and with the most effect, by being placed together. The real character of London, as a city, can be seen and appreciated only after examination; after its immense size has been repeatedly gone over; after the variety, splendour, richness, and almost countless number of its shops have been considered; after the squares and streets adjoining each other, to an extent that would form a very large town in any part of the world, without the intervention of a single street or house, that does not bespeak great opulence, have been explored; and above all, after the immensity of its population has been seen, either eager after business in the crowded streets of the city, or seeking for recreation or amusement, during a summer Sunday evening, on all the roads round the metropolis;—and after some faint and imperfect idea of its commerce has been gained, by seeing the immense number of ships that crowd its river and docks,—the warehouses that are filled with the produce and manufactures of the whole world, and by reflecting, that London may justly be deemed the centre, round which the whole commercial world moves.

II. *The history of the principal Events that have happened in London.*—By a charter of William the Conqueror, the civil government and privileges of London, as they existed in the time of the Saxons, were confirmed. In the reign of Henry I. the county of Middlesex was annexed to its jurisdiction, and the corporation were empowered to appoint a sheriff over it; and Richard I. permitted them to choose two sheriffs. In the reign of Edward I. there were aldermen and common councilmen in the different wards, which at that time amounted to 24. Edward III. empowered the lord mayor to be constantly one of the judges for the trial of criminals confined in Newgate. By another charter obtained from this monarch, Southwark was added to the jurisdiction of London. In 1381, during the rebellion of Wat Tyler, London was the scene of great tumult, outrage, and devastation. His followers burnt a great many streets, liberated the prisoners in the Fleet, Newgate, and King's Bench, and plundered the houses of the nobility, till at length Wat Tyler was stabbed by Sir William Wallworth, the Lord Mayor. Towards the end of the reign of Richard II. this monarch more than once infringed on the privileges of the city, and fined the citizens to a large amount. In 1450, the rebellion of Jack Cade occurred. Having collected a large force, he encamped on Blackheath; and afterwards, having defeated the troops sent against him, took up his quarters in the borough. Being admitted into London, he committed such outrages that the citizens at length roused themselves and repulsed him. This repulse put an end to his rebellion. In 1473, the right of choosing the lord mayor and sheriffs was vested in the masters, wardens, and liveries of the different corporations. In the beginning of the reign of Henry, and afterwards twice during the reign of Henry VIII. great numbers were carried off by the sweating sickness. In 1543, a sumptuary law was passed by the mayor and common council, by which the mayor was ordered to confine himself to seven dishes at dinner or supper; the aldermen and sheriffs to six; and the sword-bearer to four. In 1642, in consequence of the disputes between Charles I. and the Parliament assuming a serious aspect, the common council ordered the city to be fortified with out-works, and that other measures should be adopted to strengthen and defend it. Soon after the restoration of Charles II. he confirmed to the city the province of Ulster; and it is under his charter that the companies hold their immense Irish estates.

Prior to the great plague of 1666, London had frequently suffered from this dreadful complaint. It had appeared five times from 1592 to 1665, viz. in 1592, 1603, 1625, 1636, and 1665, carrying off about one-fifth of the population each time. In 1665, 97,000 persons perished by it, or on an average at the rate of 1200 a-day. The great plague first broke out in Long Acre in December, 1665. The cold of winter rather checked, it till April and May, when it again broke out in an alarming manner. In June it was particularly fatal in St. Giles'. At this time Charles with his court left London, and went to Oxford. During June and July, it had spread over St. Giles' and the greatest part of Westminster, and northward and eastward towards Clerkenwell, Cripplegate, and Shoreditch. Its ravages still continued to increase during August and September. All trade was at an end. The streets were deserted, except by those who attended the dead carts. The grass grew in the very centre of the Exchange. In the last week of August the number of deaths by the plague, according to the bills of mortality, was 7496; and it is supposed that nearly 200,000 people had by this time left London. In the three weeks of September the deaths amounted to 24,000. In the last week of September the plague began to abate. In the second week of October the number of deaths had decreased to 5000; and from this time the pestilence evidently and gradually diminished. During eight weeks, from the 8th of August to the 10th of October, the number of deaths by the plague, as returned in the bills of mortality, was 49,705; and the entire number in the year 1666 was 68,590: but as the deaths were by no means accurately ascertained, especially when the pestilence raged most violently, there can be no doubt that they were much more numerous. Since this period the plague has entirely ceased in London.

During the dreadful storm of wind in the year 1703-4 upwards of 2000 stacks of chimnies were blown down; the lead was stripped and carried off many of the churches; several houses were blown down; all the ships, except four between London Bridge and Limehouse, were broken from their moorings; 400 wherries were lost; and about 120 barges were either sunk or greatly damaged. Upwards of 200 persons were either killed or much maimed. The damages sustained in London was estimated at two millions. In 1715, 120 houses in Thames Street were destroyed by fire, and 50 persons perished. The winter of 1729-30 was distinguished by a great mortality, the deaths that year amounting to 30,000: and the winter of 1739-40 was rendered remarkable by a frost so severe, from Christmas-day to the 17th of February, that a fair was held on the Thames. In 1748 nearly 100 houses were destroyed by fire near Cornhill. From 1768 to 1771, the peace of the city was much disturbed by the proceedings respecting Mr. Wilkes, the details of which, however, more properly belong to the history of England.

On the 2d of June, 1780, the riots of London, as they are called, began, in consequence of a bill brought into Parliament for the relief of the Catholics. The rioters assembled in St. George's Fields, to the number of 50,000, with Lord George Gordon at their head. They began by destroying the Catholic chapels; and afterwards proceeded to Newgate, which they also destroyed, liberating the prisoners. They continued their devastations till the eighth of that month, when they were quelled. Two hundred and eighty-five lives were lost, besides 73 wounded. Between 20 and 30 of the most active rioters were executed. On the 23d of July, 1794, 630 houses were burnt down in Ratcliffe highway. On the 20th of September, 1808, Covent Garden Theatre—on the 1st of January, 1809, part of St. James' Palace—and on the 24th of February, the same year, Drury Lane—were destroyed by fire. In the winter, 1813-14, during the severe frost, the Thames exhibited the same appearance and scenes as it had done during the great Frost of 1739-40. See

Pennant's *London.*
Hunter's *History of London.*
Middleton's *Agricultural account of Middlesex.*
Colquhoun *on the Police of the Metropolis.*
Colquhoun *on the Police of the Thames.*
Adolphus' *Political State of the British Empire.*
Macpherson's *Annals of Commerce.*
Picture of London.
Monthly Magazine.
Selections from the Gentleman's Magazine,
Journal of a Tour and Residence in Britain. (w. s.)

LONDONDERRY is the name of a city and county of Ireland, in the province of Ulster. The prefix *London* was of no earlier date than the colonization of a part of the county, in the reign of James I., prior to which period, it was called by the English the county of *Coleraine*. *Derry* is a word of the Irish language, corrupted with an English termination, and might be translated *oaklands;* it may also mean a *dry insulated spot.*

Londonderry county is bounded on the east by Antrim, from which it is separated, for the most part, by the river Bann; on the west by Donegal; on the north by the Scottish Sea, or Deucaledonian Ocean; and on the south by Tyrone; and includes an irregular triangular figure, under an outline of about 125 Irish miles.

The aspect of the county is not uniform. At the northern border, for about three miles, there is a bold promontory at the shore, from whence, widening towards the interior, and running the whole length of the county southwards, as well as on all the Tyrone borders not adjoining Lough Neagh, it forms the main ridge, or water-shed of the county. Wild alpine regions, coarse heathy uplands, sombre boggy flats, and rough gravelly basaltic eminences, characterize this extensive mountainous region. The remainder of the county is chiefly occupied with sloping gravelly declivities, basaltic knolls, interspersed with many little spots of peat. There are schistose ridges on the western side of the Roe, near the bed of which marly flats predominate along almost the whole length of that river. Near Lough Foyle and Lough Neagh, they are in general sandy or loamy, the former of which are very much occupied as rabbit warrens. About one-fourth of the whole county seems to be bleak mountains and glens, and one half of the remainder may fitly be termed mountainous. The residue, of three-eighths, is handsome vale or valley. The principal vales are upon the Roe and Mayola, where is found the best land of the county, and upon the borders of Lough Foyle. The valleys are chiefly those of the Bann, the Roe, and the Faughan. The *slacks* of this county, as they are provincially called, are pretty inlets of low-land, embosomed within the mountains or high uplands, of which the chief are those of Laghumore, Faughan Vale, Muffglen, Feeny, Lisane, Monyniery, Ballyness, and Carntogher, at the lower end of which we meet extensive views of the richer lands of distant and more fertile regions.

The mountains of this county are nearly thirty. The highest is Sawel, towards the south, estimated at 1700 feet high; and the most magnificent is Ben-Nevenagh, in the north, about 1500 feet in height. Next to these is Benbradagh, in the centre of the county, of about 1300 feet; and at some miles distance is Alt Eglish, about the same height; Slieve Gallen, 1250; Donald's Hill, 1200; Keady, 1100 feet and upwards; besides Laghumore, Mullaghash, Banagher mountains, &c. of decreasing magnitude.

The climate of this county is moist, in a degree beyond Antrim or Down, but less than Donegal; yet it is not unhealthy, unless we except a few spots on the flat of the Bann, which are liable to be inundated during winter, or to a great passage of moisture between the sea and Lough Neagh. Although two-thirds of the days of the year, upon an average of many years, are rainy, yet the actual fall of rain per annum has not exceeded 32 inches, during ten years. Longevity from 80 to 100 years is not uncommon, more especially towards the northern shores. The range of the barometer may be stated about 28.2 to 30.89; thermometer 17 to 90; rain-gage 25 to 36 inches. The following proportion is also near the average of many years: fair weather 120 days, rainy 30, showery 200, snow falling 5, hail and sleet 10 days; also snow may prevail about 36, and frost 45 days, in a considerable portion of the cultivated districts.

The soil, as may naturally be expected, is various; but it is only the least portion, and chiefly in the vallies and flats, that can be called naturally fertile. The Author of Nature has, however, provided the means of fertilizing almost every place, except the tops of the mountains, by means of the vast beds of clay and lime enlayered in the hills, or imbedded in the rivers; and in most places of pretty easy access. The burning of the heathy and peaty soils has produced, in some places, good pasturage in what was formerly thought of little value; and the same practice on the low lands produces now excellent crops of oats. Open gravelly soil indeed predominates; but this has many varieties, from the rubble of basalt and schist to the stiff marly, loose sandy, or deep loamy gravels, near the shore.

Of the agriculture little need be said, as it owes nothing to public institutions, and only a little to private patronage. The uplands, or mountains, are usually held in large tracts by some adjacent farmer; but the arable land is divided and subdivided from 250 down to one acre; and the bulk of the land is let in pieces from three to thirty acres Irish. There are whole districts where you will scarcely find an individual holding more than from ten to fifteen acres. There is no long nor generally prevalent rotation of crops, a few wealthy proprietors, or linen-drapers and agents excepted. The people attempt only oats, and in some parts barley or flax, are raised in addition to potatoes, which is the principal crop. Rye is cultivated on light sands, and wheat begins to be raised by some of the farmers on clay or stronger soils. Hitherto clover has been much too sparingly raised, though it is greatly wanted to supply the deficiencies of the pasturage and meadows. The rotation of crops is nearly as follows: 1st, potatoes, in beds or in drills; 2d, oats, or barley; 3d, flax, or oats; and 4th, potatoes again. Oats and pasturage is but too common. A few persons have lately begun to use ashes for a top-dressing.

The crops, or produce, are not, as may be easily supposed, very great, in proportion to the actual quantity of labour bestowed, and the number of persons engaged. In no year do they seem to supply the population; but, in years of ordinary produce, they may, we believe, meet the demand for more than eleven months: in other seasons, there has been required a supply for the mass of the poorer population during three or four months in the year; but we cannot help attributing this, in a great measure, to the injurious practice of illicit distillation, too commonly followed in the counties of Derry and Donegal. But we hear this practice is gradually decreasing, and we trust it will never be revived. The use of lime and other manures, with a better system of agriculture, have greatly increased the produce, which may in time reach nearly the average demand. Of potatoes, 300 bushels per acre is reckoned good produce; of oats 70; and hay two tons.

Of manures, stable, cow-house, and field manures are the principal. Imperfect composts of these with clay, bog, &c. are prevalent. With a few, lime is much used; and near the sea, crag or wrack is much sought after. Ashes begin to be employed; and, when judiciously managed, they have been highly serviceable. This part of farming economy, so very important, is still in its infancy here, but promises to improve. There are two openings at hand for the vast improvement of this county, which have been greatly neglected. The first is irrigation, which is both practicable and easy in a very great part of the county: the second is, by a due mixture of lime with the soil on the surface, which is also comparatively easy, as it is every where abundant. These two plans, if put in practice extensively, would in a few years be the source of the highest improvement and benefit to the county at large.

Respecting fences, it is only necessary to remark, that a considerable part of the county is void of any thing deserving the name. This defect arises, in most places, from the expences necessarily incurred in making permanent enclosures. The poor farmers are very unable, though generally well inclined, to enclose their lands; but in some places, such as the sands of Magilligan, it is almost impracticable; and in other places, from the modern system of giving *short leases*, no improvement need be expected, however necessary it may be to the comfort and benefit of the dependent possessors. A small ditch and bank is the modern plan, instead of the old double ditch and bank between; but such is the coldness and poverty of the soil, that thorn and other plants inserted would require manure, which they seldom receive. This department calls loudly for the interference of the wealthier part of the community, to stimulate and encourage the peasantry in general.

The cattle and stock of this county have few peculiarities that are worthy of notice: probably the average size of them may be a little larger than most of the same breed in Donegal, and less than those of Antrim and Down. A mixed breed from some of the upper counties has lately been of use to the farmer. All sorts of domestic cattle are plentiful, but not sufficiently fed either in winter or summer, especially horses and cows. Butter is not high, yet very little is made for exportation, where a better market might be found. After the Revolution, the present breed of sheep was introduced from Scotland: they are rather small, and are recruited from Donegal and Antrim. A few excellent cattle are kept by some gentlemen of the county. Pigs are reared and fattened by almost every householder; and the goat is still retained in many places, especially in the uplands; and it is no uncommon thing to see the poor beggar, who has neither house nor home, with his goat browsing on the countryman's hedge.

The prices of labour in this county are much on the decrease. A man-servant that, during the late war, received 5*l.* or upwards for the half year, can now scarcely get 3*l.*, and the average price is even lower. Female servants receive from 1*l.* to 1*l.* 15*s.* per half year: these board and lodge in the master's house. Ten pence per day, with victuals, in time of harvest, is still expected by the day-labourer. The wages of mechanics are a little higher than in the county of Donegal, and not so high, in general, as in Antrim or Down. See DONEGAL and DOWN.

The prices of provisions are variable. Butter, eggs, and especially butcher's meat, are usually a little lower than in North Britain. In the time of a general dearth, oatmeal and flour are frequently higher. At present (November, 1817,) beef sells at from 2d. to 3d. per lb. of 16 ounces; good mutton and pork from 3d. to 3½d. do. Cod-fish 5s. 6d. per dozen; oatmeal 3s. 4d. per score of 20 lb; potatoes 20d. per bushel; butter 8d. per lb.; cheese 5d. do. But as want of money and heavy rents oblige the poor farmers to sell at any value, in order to pay the November rents, the prices will probably be much higher in summer. The loaf of white bread is smaller than in several other places, where wheat is more generally sown, and consequently cheaper, and more easily procured. Last summer, oatmeal, the principal food for the mass of the people, during summer was for a time 7s. 6d. per score.

Peat, provincially called turf, is the fuel in this county, as well as that of Antrim and Donegal, &c. a few of the wealthier families, and part of Derry, &c. excepted. The material from which the turf is procured is termed bog. Hitherto, the supply in most parts of the county is abundant, and, in a considerable portion of it, will remain so for many years to come. It requires, however, no great discernment to perceive, that all the maritime parts, and some of the interior, will soon be obliged to have recourse to coals, and probably from Scotland. The turfs are mostly of the best quality; but the continual waste of about 45,000 house-fires, and 15,000 in the fields, burning ashes, must rapidly exhaust the material, in a county so populous. The reclaiming of the bogs will, however, afford good land.

Plantations of a small size, in this county, are to be met with in many places, at once useful and ornamental. Those of Somerset, near Coleraine; at Lisance, Nolworth, Downhill, Daisyhill, &c. are considerable. Firs predominate, and latterly the value of larch is becoming better known. Sir George Fitzgerald Hill, and others near Derry, have rendered even small plantations highly conducive to the pleasing and picturesque. There are but few old trees, and generally the county is supplied with timber from Norway, &c.

The minerals of this county deserve peculiar attention from the gentlemen of property, and others in the county. Basaltic layers, apparently not much dissimilar to those of Arthur's Seat, near Edinburgh, interlayered with white lime, clays, zeolite, &c. occupy the region east of the Roe. Schistose ridges, intermixed with quartz and veins of blue lime, &c. fill up the western regions. Granite, martial pyrites, &c. form the base of the Slieve Gallen, and the other southern mountains. Freestone and sandstone are found in the interior of the county; also those beautiful rock crystals, which, when cut, are termed Irish diamonds. Probably the indication of coal, in different places, will lead to useful discoveries, as the fuel becomes scarcer; but, at present, nothing worthy of notice seems to occur respecting them. Iron is thought to be very abundant, from the profusion of its ochreous and other ores, and may be seen partially smelted in the farmer's pits of ashes. Copper and lead have been seen in small quantities; chalcedony also, in the basaltic promontories. Lime is at no great distance from any part of the county.

The present rental of the county is not easily estimated with any degree of precision. At the settling of proprietorship, about A. D. 1604, when the lands were considered as forfeited to the crown, we may reckon about eleven-eightieths of the value assigned to the Primate of all Ireland, the Bishop and Dean of Derry, and 2125 acres to the resident incumbent; also 4000 acres to the superintendant of the division of the county, of the best lands. All the rest of the lands was assigned to twelve companies, or guilds of London; but from the subdivision since made, and the diversified leases and tenures, the county has now about a dozen principal holders of land, 20 of a secondary, and 300 of a still lower order; add to this, the numerous cases of part, and sometimes all, of the farm lands reset to poor cottagers or householders, (by some thought a ruinous practice,) and the rent of houses in large towns, it is calculated that the whole will probably, ere long, amount to a gross sum of about £350,000 Sterling per annum: hence the average rent per acre is about 20s. which is higher than some of the best lands in the fertile province of Normandy in France! The same remark applies to the lands of county Antrim, which are generally higher than those of Derry.

The county of Derry, with the exceptions already mentioned, is divided into twelve proportions, which are held by the present proprietors from the above mentioned companies; four of the proportions are granted in perpetuity, and eight are determinable leases. The following is a list of the proportions, and by whom held: The proportion of the Draper's company has lately fallen out of lease, and the company have taken it into their own hands: the late proprietor was Sir William Rowley, chief town Moneymore. The Salter's proportion is a lease of years: the present proprietors are, Lord Londonderry, and Mr. Bateson, chief town Magherafeldt. The Vintner's is granted in perpetuity: the present proprietors are, the heirs of the late Right Honourable Thomas Connolly, chief place Bilaghy and Tabermore. The Mercer's proportion is a terminable lease: the proprietor is Alexander Stewart, Esq. brother to Lord Londonderry, chief place Kilrea. The Ironmongers' is a terminable lease: the proprietors are, Marshal Beresford, Captain Beresford, and Sir George Hill. The Merchant Tailors' is granted in perpetuity, and Mr. Richardson holds a proportion of it in the neighbourhood of Coleraine. The Clothworkers' is a determinable lease, and the assignees of Mr. Hannington hold the N. E. proportion from Coleraine. Robert Ogilby, Esq. holds the largest proportion in the county; it is the Skinners' proportion, being a determinable lease. The Marquis of Waterford holds the next proportion to the North, in perpetuity; it is called the Haberdashers'. His cousin holds a proportion during the king's life, called the Fishmongers'. The Goldsmiths' proportion is held by the Ponsonby family in perpetuity; and the Grocers' by David Babbington, Esq. on a determinable lease of years. Robert Ogilby, Esq. holds, also, the sixteen townlands of Newtonlimavady, a grant from all the companies in perpetuity; as does likewise George Dawson, Esq. the eight townlands of Mayala. Mr. Canning of Garvagh has a neat little estate; Sir Henry Bruce has a great deal of Church lands; Sir A. Ferguson, Mr. Cunningham of Springhill, the Bishop of Down and Connor, and Marcus Gage, Esq. are all respectable landholders in the county.

The three principal rivers in the county are the *Foyle*, (that is, the *green river*:) it runs only a few miles until it expands into a lake of the same name, yet it is the broadest and greatest flow of water in the county, being navigable for any merchant vessel up to Derry, and for lighters of 20 tons up to Strabane. The flat wooden bridge over this river at Derry is a late elegant erection. The *Bann*, (that is, the *white river*,) on the borders of Antrim, issues out of Lough Neagh at *Toome*, (*i. e.* a bush,) where there is a superb bridge, erected by the late Lord O'Neill, after passing which, it expands into the beautiful Lough *Beg*, (*i. e.* the *little* Lough,) forming several islands, passes by Portglenone and Coleraine, four miles below which it meets the sea, over a shallow bar, admitting vessels only at proper times of the tide. The sum of 20,000*l* might render it navigable. On it are erected several eel weirs; and it is famous for its salmon fishery at the leap of Coleraine. The roe (that is, the *red river*,) passes by Dungiven and Newtonlimavady, through a beautiful and very fertile country. The two rivers of greatest note, next to those already mentioned, are the Faughan and the rapid Mayola; the first empties itself into Lough Foyle, and the Mayola into Lough Neagh, which only washes a few miles of this county on the north-east. Lough Foyle on the north western extremity is only an expansion of the river. It approaches to the form of a triangle of about 9, 12, and 15 miles in the sides; a great proportion of it is dry at low water; but the principal current is 15 fathoms deep. The tan banks are a little off the mouth, from Magilligan point, where it is one mile wide. Lough Foyle affords a tolerably good harbour, only there is a difficulty of entering it safely with a stormy west wind: a canal from it to Lough Swilly, only four miles distant, would be highly useful; and another from it to the Roe would be easily accomplished, as the distance is only two miles, and the land level in both cases. The Bann affords a harbour for small vessels, occasionally, up to Coleraine; but Portrush, four miles below it, is generally preferred for vessels of any tolerable burden. Ballyronan is a thriving little town, having a port on Lough Neagh for small vessels trading on the lake, and is well situated for increasing trade.

The fishes on the coast of Derry are, lampreys, sturgeon, sun-fish, haddock, turbot, &c. more especially flounder, salmon, eels, and codfish. At Culmore, (*i. e.* the *great Corner*,) near Derry, is a salmon fishery; but the principal one is at Coleraine. In 1780, 400 tons were sold at 1¼ per lb. but they do not now average above 100 tons per annum. The eel fisheries at Toome, and the smaller ones down the Bann, may average abost 2000*l.*

The linen manufacture is the staple of this county. Flax-seed is sometimes saved by the farmers, but in general they depend on America, Holland, and Riga, for their seed: About 14 pecks of seed is sown per acre, which, on good ground, may yield about 196 lbs. of rough flax for the mill, or 54 dressed there, and perhaps 69 if dressed by hand. The cloth is made of 27, 32, or 38 inches wide, and about 25 yards when divided, or 50 when undivided, in length; and sold in a few of the provincial towns. There are many bleaching-greens, and the process of bleaching has been much improved; when finished, it is sold again in Dublin, Liverpool, London, and the foreign markets, in some years to the amount of 600,000*l.* sterling. The cotton manufacture is only known by a few, in three or four places. Woollen cloth is wrought only for blanketings, and the clothing of the poorer part of the peasantry.

The towns of this county are not numerous in proportion to the population—a few only are handsome. Besides Londonderry, the capital, there is the neat and populous town of Coleraine, once giving name to the county situated on the Bann; which, with its suburbs, may contain about 9000 inhabitants. Newtonlimavady in the northern, and Magherafelt in the southern portions, are both neat and well-built, and have a considerable trade. Next to these is Dungiven, a central town, imbosomed in mountains. Moneymore is remarkable for its horse fair held every month; Castle Dawson, for its good soil, fuel, and plantations; Maghua, for its thriving markets; Garvagh, for its plantations; Desartmartin, for its lime; Ballymacguiggan, for its Moravian settlement; Tobermore (i. e. *Great well*,)is also deserving of notice on account of its well; Belaghy for its bogs; Kilrea for its natural elevation; Agivey for its pottery; Clady and Banagher for their rural vicinages; Muff and Ballykelly for their views of the sea; Port Stewart and Portrush as the resort of bathers. There are ten market towns, and about twenty-five places where fairs are held for cattle.

The political divisions into baronies amount to four, viz. Loughinshallen in the south-east, the most populous; Tyrkeerin, south-west; Kennaught, north-west; and Coleraine: these are subdivided into 35 parishes, beside the city and liberties of Londonderry, and the town and liberties of Coleraine. Since the Union, this county returns only two members to the Imperial Parliament, with one for the city of Derry, and one for the town of Coleraine. It formerly returned eight members to the Irish Parliament.

Of the parishes, the most remarkable, for wild majestic scenery and grandeur, is Tamlaghtard, or *Magilligan*, on the northern shore, and the most wild and uncultivated is *Ballynascreen*, in which, at the little village of *Cross*, is a famous classical school, taught by a Mr. Murphy, where a large proportion of the Roman Catholic priests receive the rudiments of classical literature. The civil and ecclesiastical division of the parishes mostly coincide. Clandermot, Faughinvale, (with Templemare adjacent, in Donegal,) are attached to the deanery of Derry; Dumbœ is an archdeaconry: Dungiven and Ballyrashane are vicarages. The others generally rectories; Kilrea and some others are of recent date. Five of the parishes in the south of the county, with six churches, belong to the primate of Armagh. The remainder, with about 24 churches, belong to the diocese of Derry. The diocese of Derry includes also the barony of Innishowen in Donegal, some of Tyrone, and a small portion of Antrim, having an extent of 60 by 55 English miles, and an area of 659,000 acres. The income is estimated at 12,000*l.* sterling, arising from the rents of lands. The inferior benefices of the rectors, &c. may vary from 300*l.* to 1500*l.* per annum, and probably average 500*l.* which are raised from tythes of grain and hay, or some settlement by cash in lieu of it. The Catholic clergy are paid by their own hearers. It is probable the sum does not average 120*l.* The Presbyterian clergy are paid by a settled annual stipend, varying from 60*l.* to 120*l.* per annum, besides a grant of royal bounty by classification, varying from 50*l.* to 100*l.* per annum; and a few seceding congregations, varying from 40*l.* to 70*l.*

The extent and population of this county may be stated as follows. In the S.S E. direction it is about 32½ Irish miles in length, and about 25 in breadth, including an area of 318,500 Irish, or 511,688 English acres. By a census taken in 1813, it contained upwards of 186,000 inhabitants, or 233 for every British square mile,—a population about fourfold that of Scotland, in the same extent of nearly similar land in point of fertility. Of this population, 27,000 are Episcopalians, 53,000 Presbyterians, and 106,000 Catholics. There are some respectable schools, especially in Derry. The ancient establishment, which was founded by James I. coeval with the city, had been built within the walls. The disadvantages of such a situation did not escape the attention of the present Bishop of Derry, who has been ever watchful for opportunities to originate or amend establishments of every kind, whose object is the public good. By means of a generous contribution from his Lordship's private purse, and by means of an extensive influence among the great companies of London, who are the chief proprietors of this county, the Bishop has been enabled to erect a new and ample school-house on the bank of the river Foyle, within half a mile of the city. The same extensive influence has also been successfully exerted in obtaining annual grants for the endowment of the school institutions, all of which have in view the extension and combination of local with public and general advantages. We regret that our limits do not permit us to give a more detailed account of this, as well as many other useful institutions which have been created and fostered under the generous patronage of this benevolent prelate.

In general, however, the state of education throughout the county is, like that of the rest of Ireland, in a state of comparative neglect. Yet better hopes begin to arise—the general disposition of the lower classes begins to turn towards education; and, already, suitable masters may be found in the towns, villages, and country parishes, towards which last the clergy of the establishment are the principal contributors. See Beaufort's *Memoir of a Map of Ireland*; Sampson's *Statistical Survey of the County of Londonderry*, from which the above is partly drawn; but the writer of this article has had access to much original information from various quarters. (c)

LONDONDERRY, City, the capital of the foregoing county, is beautifully situated on the banks of the *Foyle*, chiefly on a piece of elevated and almost insulated land, which is connected with the county of Donegal by a flat of boggy loamy land, once perhaps the ancient passage of the river. It is thus mentioned in the ancient *Book of Howth*: "Five y$_e$ greatest towns y^t were in ancient times in Ireland; that is to say, Ardmagh, *Dere Columb-Kill*, Drumcloo, Kellsin, Meath, Fayle-mew." And the chiefs of the lands on the same western bank were called *Hy-daher-teagh*, that is, the "chiefs of the oak habitations," now generally written by the names O'Dougherty and Dougherty; and from the abundance of *oaks* in former times, it well merited the appellation. The inhabitants of the adjacent regions were the *Darnii* of Ptolemy. The ancient records of the place are little known prior to Columb-Kill, whose history and actions form a prominent part of them.

Our limits will not permit us to detail much of the history of this place. Both the abbey and town were burned, A. D. 783; and upon being rebuilt, were consumed 29 years afterwards, by the Danes, who massacred the students and clergy; but they were, in the year 832, driven from the place with incredible slaughter by Neil Calné, monarch of Ireland; yet they made afterwards many successful attacks on it, in one of which, Maol Leaghline, in 985, carried away the shrine of St. Columb, and returning at periods of four, six, and eleven years after, committed great depredations. O'Brien, prince of Munster, with his people, made several incursions into this district, and in the year 1134, succeeded in burning most of the town, and all the sacred edifices in it. Having been repaired by Abbot O'Bralchain, it was, in 1158, made an episcopal see, and the Abbot consecrated first Bishop. Six years hence was erected the cathedral on a large scale: conflagrations happened again in 1170 and 1203. In 1218 a nunnery was erected, and in 1274 a priory. But waving these and other particulars, it is observable that the charter was first granted to the London Company in 1515; the battle of Randolph with O'Niel of Ulster took place in 1565; and the forfeiture of the place by Sir Henry Dochra, in 1600. Seven years afterwards, this place, with six counties, were escheated; and though Sir Cahir O'Dogherty, the chief of Innishawn, treacherously seized and burned the town in 1608, yet, as soon as peace and order were restored, the walls of the city were erected. In 1614, their length was 5124 feet, besides four gates, each 21 feet, the thickness 6, and height 24. The families at this time were 102. The place was again besieged, and rescued from the Irish in 1641. It was in 1649 besieged by the same party, but the attack was unsuccessful. In 1688, it was attacked by the whole Irish forces under King James, from the month of December 1688, till August 1689. In this memorable siege, the apprentice boys of the city, in a paroxysm of ardour, just as the enemy appeared within *three hundred* yards of the Ferry-gate, raised the drawbridge, and locked the gates; the enthusiasm of *nine boys* was soon communicated to the populace, and the citizens, reinforced from the country, resolved on the most vigorous defence. After being almost betrayed by the governor, Lundy, who was on the point of giving up the city to the enemy, they chose the celebrated George Walker, Episcopalian rector of the parish of Donaghmore, (afterwards killed at the battle of Boyne,) with one Major Baker, for their governors. The citizens, under these brave commanders, foiled the attacks of the whole of James' forces. The sufferings and privations of the garrison during the siege, equal any thing to be found in the records of history.

Derry has four main streets within the walls, which are now its ornament, and mall, with a public terrace, or diamond, in the centre. They cross at right angles, and form, with the lesser streets and lanes, a sort of parallelogram of 1273 by 635 feet. On the declivity of the ground, neither the streets or roads are easy levels; and here the use of carriages, though very common, is not convenient in a considerable part of it. Paving and lighting have not been neglected; and as the gentlemen of Derry and its vicinity have usually a great influence in the expenditure of the money raised by the county, nothing has been omitted to render the city and vicinage as elegant and serviceable to the public as its local inconvenience will permit. The cathedral is of the gothic style, and was first erected by Sir John Vaughan in 1633. Its organ is esteemed valuable. Besides the cathedral, or high church, there is a Chapel of Ease, endowed by the representative of the famous Bishop Bernard, also two Presbyterian meeting-houses, and a Roman Catholic chapel in the city. The central market-house, or town-hall, dates from 1692, and contains the guard-room, &c. upon seven neat arches. There is a large and commodious gaol, esteemed the best in the northern counties, and an elegant court-house, built at great expense. A school, for the education of the lower orders, has been built at the expense of the Board, of Erasmus Smith, and of the Bishop; the Board contributing three-fourths towards the building, and 60*l.* a year to the support, of it; and the Bishop contributing one-fourth to the building, and ten pounds annually to the support of it. An Infirmary has lately been erected, on a very large scale, at the expense of the county, and supported by voluntary contributions. These buildings are on lands held under the See of Derry. There are a small theatre, a linen hall, with shambles, fish booths, wharves, and quays, in very good repair. In 1790, a very valuable and elegant wooden bridge was thrown over the river at this place, by Samuel Coxe, of Boston, in America; the length was 1068 feet, the breadth 40, depth of the water at low tide 31, and 48 feet at spring tides. This, having been in a great part thrown down in the winter of 1813, by the ice and a tremendous flood, has been since repaired. The principal markets are held on Wednesday. The fairs for cattle are held on June 17th, September 4th, and October 17th. Both fairs and markets are famous for supplies of flax, linen yarn, and coarse linens.

The inhabitants import and sell flax-seed, hardware and earthenware, iron and timber, to a considerable amount, and also West India goods. Their exports are, yarn, linen, &c. but the vessels belonging to its port are very few, compared with its opulence. They have a weekly newspaper, called the Londonderry Journal.

The corporation consists of 12 aldermen, one of whom is mayor, 24 burgesses, 1 chamberlain, and 2 sheriffs; and the estate annexed to the city was computed at 4000 acres. The population, including the suburbs, is about 18.500. There is a military governor of the fort of Culmore. Its distance from Belfast direct is 59 miles, and from Dublin 115. North Lat. 55°, West Long. 7° 15′. (G)

LONGEVITY. The desire of self preservation is one of the first principles of our nature, and has been implanted in us for the wisest purposes. While it excites to labour and exertion in procuring the means of supporting our mortal existence, it reconciles us to bear with patience many distresses and pains, which are more or less the inevitable lot of all. But though this feeling is possessed, in a greater or less degree, by almost every individual, it may be wondered at, that the preservation of health, and the prolongation of life, subjects of such importance to the generality of mankind, should be so much overlooked. Even few of the medical profession have made them their particular study. Their researches have been, in general, directed rather to the cure than the prevention of disease; and while thousands are daily falling sacrifices to the pernicious effects of luxury, and the factitious rules of an overstrained civilization, the inquiry has seldom been made, what mode of living is most conducive to health and an extended existence? If health be the most precious boon of life, which gives a relish to all our other comforts, and without which life is only a burden, what inquiry can be more important, or more generally useful? And the gratitude of the human race is due to those men who have devoted their talents to this subject. A condensed view of the principles of health and longevity, in a cheap form, so that it may be accessible to the lower classes of society, is still a desideratum; and it is also to be regretted, that while the names of many who have attained to long life have been preserved, their history, as far at least as relates to their diet and regimen, has been lost. We are aware that the duration of life depends not on manners and customs, and that no attention to rules can secure us against the contagion of disease, or prevent those accidents which cannot be foreseen. But no one will deny, that by following a regulated system with respect to diet, sleep, &c. we may add many years to our existence. It would indeed be difficult to form a particular set of directions which would be applicable to the various constitutions and employments of mankind. But there are general rules, which all may follow with safety and advantage; and the advice of the celebrated Galen is adapted to every situation in which man can be placed: "Consult your reason," says he, "and observe what agrees and what does not agree with you, that, like wise men, you may adhere to the use of such things as conduce to your health, and forbear every thing which, by your own experience, you find to do you hurt; and be assured, that, by a diligent observation and practice of this rule, you may enjoy a good share of health, and seldom stand in need of physic or physicians."

The principles of longevity, or the circumstances essentially necessary for the preservation of health, and the attainment of long life, may be comprised under the following heads: 1. Parentage; 2. Air; 3. Diet; 4. Exercise; 5. Sleep; and, 6. The government of the passions.

1. *Parentage.*—An exemption from hereditary disease is evidently favourable to longevity; and, as it is fully ascertained that disease is transmitted from father to son, it cannot be expected, in the nature of things, that unhealthy parents can produce a healthy offspring. The father, who, by a course of vice and intemperance, has brought disease and debility into his frame, entails them upon his posterity; and the mother, who spends her nights in fashionable follies, and her days in listless idleness, may bring a child into the world; but the tender plant is unable to resist the first blast of disease; and should it struggle through the years of infancy and childhood, its feeble frame is liable to be shaken by the slightest vicissitudes. No doubt much may be done by proper care; and a healthy nurse, wholesome air, regular exercise, and medicine, may ward off, for one generation, the effects of family disease; but even these can never sufficiently supply the defects of constitution. It is a doctrine as old as Hippocrates, and may be considered as a general rule, that healthy parents will have healthy children, and that descent from long-lived ancestors gives the greatest probability of attaining to old age. This rule is acted upon with the fullest confidence in the rearing of animals for the sports of the field. The sportsman knows well that the generous courser cannot be bred out of the foundered jade, nor the sagacious spaniel out of the snarling cur. It is also confirmed by the reports transmitted to Sir John Sinclair from Greenwich and Kilmainham hospitals, and from the workhouses in London and the neighbourhood. Of 598 individuals who were above 80 years of age, 303 affirmed that they were descended from long-lived ancestors; the remaining 295 either could give no account of their parents, or declared that there was nothing remarkable in regard to their longevity. It has likewise been observed by Dr. Jameson, that most of the great ages recorded on monumental stones, in the church yards of Cheltenham, and the neighbouring villages of Gloucestershire, run in particular families.

2. *Air.*—As our existence depends upon the respiration of atmospheric air, without which we could not live many minutes, it is of the utmost advantage to health that we breathe it pure, and void of all noxious exhalations. Unwholesome air is the parent of many diseases. Few are aware of the danger arising from it; and while all are anxious about what they eat or drink, they pay little attention to what they breathe, which is more essential to health, and which often proves more suddenly fatal to their existence. Common air, in its respirable state, is ascertained to contain $\frac{21}{100}$ parts of oxygen or vital air, and $\frac{79}{100}$ parts of azote, combined with a small proportion of water and carbonic acid. Whatever, therefore, has a tendency to reduce the quantity of oxygen, renders the air in a proportionate degree impure and hurtful. As air also is a principal agent in the decomposition of bodies, it is often replenished with those noxious qualities which are destructive to human life. Hence arises the vitiated state of the atmosphere in crowded cities. The air is not only breathed repeatedly over, but is likewise loaded with sulphur, smoke, and other exhalations, arising from numerous putrid substances; while, in the country, oxygen is exhaled from the green leaves of every tree and shrub, by which the air is so much the more improved as a mean of life. It is from this circumstance that the inhabitants of the country are, in general, longer lived than those who reside in populous towns; and it has been calculated, that while the average duration of life in the former is 41 years, that of the latter is only 36. Wherever air is allowed to stagnate, it becomes unwholesome; as is evident from the malignant diseases which

prevail among those unhappy persons who are confined in gaols, and among the poor in the crowded lanes of a city. Hence the necessity of daily ventilating our houses, and of admitting a current of fresh air into every room. The method of expelling foul and introducing fresh air, by means of ventilators, is a most salutary invention, and is, indeed, the most useful of all our modern medical improvements. It is capable of universal application, and is fraught with numerous advantages both to those in health and sickness. Of the truth of this, an instance is given in the case of the Dublin lying-in hospital, where, in the space of four years ending 1784, no less than 2944 infants, out of 7650, died within a fortnight after their birth. It was suspected that this mortality arose from the want of pure air. Ventilators were then fortunately introduced into the hospital, in consequence of which the proportion of deaths was reduced to 279. Thus, above 660 lives were annually saved in this establishment, by the simple process of ventilation. According to Dr. Buchan, air may become noxious to human life in many ways. "Whatever greatly alters its degrees of heat, cold, moisture, &c. renders it unwholesome. For example, that which is too hot dissipates the watery parts of the blood, exalts the bile, and renders the whole humours adust and thick. Hence proceed bilious and inflammatory fevers, cholera morbus, &c. Very cold air obstructs the perspiration, constringes the solids, and condenses the fluids. It occasions rheumatisms, coughs, and catarrhs, with other diseases of the throat and breast. Air that is too moist destroys the elasticity or spring of the solids, induces phlegmatic or lax constitutions, and disposes the body to agues, or intermitting fevers, dropsies," &c. The advice of Dr. Darwin to the people of Nottingham shews the importance in which he held pure air as conducive to health. He recommended to them to open the windows of their sleeping rooms whenever they quitted them to go to their work-shops; and to keep the windows of their work-shops open whenever the weather was not insupportably cold. "Remember," says he, "what I, your countryman, and a physician, tell you: if you would not bring infection and disease upon yourselves, and to your wives and little ones, change the air you breathe: change it by opening your windows several times a day."

3. *Diet.*—Moderation in eating and drinking is certainly of great importance in regard to health. There are no doubt several instances of intemperate people living to a great age; but these must be considered as merely exceptions to a general rule. It is, however, no easy matter to ascertain the exact quantity of food proper for every age and constitution. The best rule is, to avoid all extremes. Nature teaches every creature when it has enough; and the calls of thirst and hunger are sufficient to inform them when more is necessary. Attention to the *quality* of our aliment is of equal importance to health as a regard to the quantity. Food, otherwise sound and good, is often rendered unwholesome by being improperly kept, or by the arts of cookery. All who value health should be content with plain fare, and make only one meal of flesh in the twenty-four hours. Neither should our food be too moist or too dry. A moist diet relaxes the solids, and renders the body feeble; while food that is too dry renders the solids too rigid, and the humours viscid, which disposes the body to scurvies and inflammatory fevers. Our diet, however, should not only be adapted to the constitution, but to the manner of life; and a person of a studious and sedentary habit should live more sparingly than he who leads a life of exercise or of labour. Dr. Cheyne, in his Essay on Health, recommends eight ounces of flesh-meat, twelve of bread or vegetables, and about a pint of wine or other generous liquor, in the twenty-four hours, as sufficient to keep a man who follows no laborious employment in proper health and vigour; and he adds, that the valetudinary, and those employed in sedentary professions or intellectual studies, must lessen this quantity, if they would wish to preserve their health, and the freedom of their spirits. *Regularity* in diet is also requisite to promote longevity. Too long fasting is often attended with very injurious consequences: it weakens the stomach, exhausts the spirits, and is equally destructive with gluttony to the powers of digestion. Too much nicety, however, respecting either the quantity or the quality of our food, is not necessary. A rational enjoyment of the gifts of nature is certainly allowed us; and the happy medium lies between boundless indulgence and unnecessary self-denial. Moderation both in food and drink, indeed, is the best nostrum for the prevention of disease; and every man's experience of what he has found to agree or disagree with him, will point out what is best calculated for his stomach and constitution. Abstinence and excess are equally to be avoided. To exceed, however, a little in quantity, is safer than to fall short; for the damage of a more full diet is soon remedied, either by exercise or gentle evacuation; but the decay of strength, the natural consequence of too spare a diet, is not so easily repaired. Excess, however, of every kind, when frequently indulged in, is most destructive to health. The stomach, after having been often distended by repletion, feels uneasiness from the least vacuity, and acquires an unnatural craving, the gratification of which produces heaviness, debility, and disease; and drinking to excess causes a faintness and depression of spirits, which can only be removed by having recourse to the favourite beverage, which proves not only destructive to health, but likewise to the faculties of the mind. But whatever be the quantity or quality of our food, the health and nourishment of the body depends entirely upon its proper and regular digestion, and the consequent discharges. Attention to this point, therefore, is of the utmost importance with a view to health; and whenever there are any continued irregularities in these important functions, they must be attended with disease.

4. *Exercise.*—From the structure of the human frame, it has been maintained that exercise in the open air is absolutely necessary for the preservation of health. This is evident from the robust and healthful appearance of those persons whom poverty obliges to labour for their daily bread, particularly of those who live by the culture of the ground. The love of activity shews itself in all our early amusements; and it seems to be an universal law throughout the animal creation, that no creature without exercise should enjoy health. It is by exercise that the digestive secretions are prepared; that the alimentary juices are absorbed and incorporated with the the system; that the blood is duly circulated, perspiration promoted, and every noxious substance expelled. Inactivity, on the other hand, never fails to induce an universal relaxation of the solids, which disposes the body to innumerable diseases. Glandular obstructions and nervous complaints are, in general, the invariable consequences of want of exercise; when the matter which should be thrown off by perspiration is retained in the body, it vitiates the humours, and occasions gout, fevers, rheumatisms, and similar disorders. Every man there-

fore should lay himself under some necessity of taking regular exercise, by walking, running, riding, digging, &c. which would prevent many of those diseases which cannot be cured, and remove others where medicine would be ineffectual. There are various diversions which afford excellent exercise, as hunting, shooting, playing at cricket, bowls, handball, golf, &c. which last has greatly the preference over all those athletic amusements which cannot be followed without violent exertion, as it may always be taken in such moderation as neither to overheat nor fatigue. These exercises not only promote perspiration and the other secretions, but also strengthen the lungs, and give firmness and agility to the whole frame. It is to be regretted that so many of the lower classes, who are confined the whole day by sedentary occupations, should pay so little attention to exercise in the open air. Instead of joining in those athletic diversions in which their ancestors delighted, such as leaping, wrestling, foot-ball, putting the stone, &c. they spend their leisure hours in lounging in the streets or in the ale-house.

5. *Sleep*, which is as necessary to our existence as food, requires also to be duly regulated. It has been observed, that it cannot be safely dispensed with for any length of time; and if it does not pay its accustomed visit, the whole frame of the unfortunate individual is thrown into disorder, his appetite ceases, his strength fails, his spirits become dejected, and he is reduced to a state of the utmost misery. Too little sleep weakens the nerves, exhausts the spirits, and occasions diseases; and too much renders the mind dull, the body gross, and disposes to apoplexies, lethargies, the stone and gravel, and other complaints of a similar nature. But there is considerable difficulty in fixing the medium most proper for the purposes of health; for the quantity must depend much upon age, constitution, occupation, and mode of living. Young persons require more than adults, the laborious more than the idle, and those who use a full and generous diet more than the abstemious. Between six and eight hours, in most cases, is supposed sufficient; but, that it may promote those purposes for which it is intended, the renovation of our vital and mental energies, it must be sound and refreshing. Broken and disturbed repose, accompanied with fearful dreams, greatly tends to weaken the constitution; and this is occasioned generally by indulging too long in bed, by want of sufficient exercise through the day, or by eating a heavy meal before going to rest. Anxiety of mind also banishes sleep; and this greatest of human blessings, "tired nature's sweet restorer," flies the wretched, while it visits the couch of the happy and the cheerful. In order, therefore, that our slumbers may be tranquil and refreshing, temperance, moderate exercise, composure of mind, and especially early rising, are indispensibly requisite. The plan of going to bed early, and rising betimes, has been called the golden rule for the attainment of health and long life. It has been confidently asserted, that while men of every occupation and in every situation of life have attained to old age, and that some even have enjoyed this blessing who have by no means led regular lives, all very old men have been early risers. "This is the only circumstance attending longevity," says Dr. Buchan, "to which I never knew an exception; and I hardly ever knew an early riser, who did not enjoy a good state of health."

6. *The Government of the Passions.*—There is established such a reciprocal influence between the mental and corporeal powers, that whatever injures the one disorders the other: and a large proportion of the diseases to which we are subject originate from the influence of the passions on the human system. Nothing, therefore, can be more conducive to longevity, than to keep the passions under due controul, and to preserve as far as possible equanimity and good spirits.

> "'Tis the great art of life, to manage well
> The restless mind." ARMSTRONG, b. iv. l. 84.

Many fall a sacrifice to the effects of anger, grief, or fear; and each of these passions may boast of having killed their tens of thousands. Anger ruffles the mind, hurries on the circulation, and disorders the whole vital and animal functions; and when carried to an extreme, often terminates in fury and madness. Fear and anxiety, by depressing the spirits, not only dispose us to disease, but often render those diseases fatal, which an undaunted mind would overcome. Grief is more destructive, and more permanent in its effects, than either. When indulged, it often changes into a fixed melancholy, which preys upon the spirits and wastes the constitution. Experience indeed shews that many perish from despondency, who, if they had preserved their spirits and vigour of mind, might have survived many years longer. Neither the irritable, who are agitated by trifles, nor the melancholy, who magnify the evils of life, can expect to attain to a great age. It is the interest, therefore, as well as the duty, of all who have any regard to their health, to keep these sources of disease and misery under due subjection, and nothing can be more conducive to this, than to regulate our lives by the dictates of religion and virtue. A cheerful temper is the sure attendant of true religion; and cheerfulness is one of the principal characteristics of longevity.

From these principles, which we have stated as fully as our limits will admit, we may safely conclude that those persons have the best prospect of longevity, who are born of healthy parents; who breathe a pure air, and are moderate in their diet; who take regular exercise without incurring fatigue, and sleep so long only as is necessary for restoring vigour to body and mind; and who keep their passions under due subjection, and bear with fortitude and resignation the disappointments and trials of life.

Longevity is not confined to any particular nation or country; for instances of it may be found in every quarter of the world. It prevails, however, more in some districts than others, and the majority of instances occur in cold and temperate climates. Heat relaxes and enfeebles the body, and the diet of hot countries is of a less strengthening nature. Warm climates, however, are more favourable for the rearing of children; but there the age of puberty is earlier. The inhabitants consequently become older much sooner than in colder regions, and few of them reach their sixtieth year. In proof of this, we may adduce the order issued by Kien Long, emperor of China, in 1784, for assembling before him all the old men in his empire. Yet throughout his extensive dominions, and out of a population of above 200,000,000, four persons only could be found whose several ages exceeded a hundred years.

In cold countries fewer of the children attain to manhood, but instances of longevity are by far more numerous. In Norway, of 6929 persons who were buried in 1761, sixty-three had lived to the age of a hundred; and in Russia, out of 726,278 souls, who died in 1801, 216 were 100 years of age, and 220 above it, of whom four are stated to have been above 130 years old.

Temperate climates, however, are best calculated both for the preservation of health and the attainment of longevity. There the human frame is most complete, the body most vigorous, the mind the best formed, the passions the best regulated; and man in every respect reaches, when well governed, the highest degree of perfection. The districts of Arcadia, Ætolia, and other parts of Greece, were celebrated for longevity; and many of the most distinguished Greeks, such as Pythagoras, Plato, Sophocles, Pindar, &c. attained to a great age. In Italy, when a general census of the Roman empire was made by Vespasian in the year 79, Lord Bacon assures us that there were then living, between the river Po and the Appenines,

	54 persons of	100 years of age
	57 - - -	110
	2 - - -	125
	4 - - -	130
	4 - - -	136 and
	3 - - -	140
In Parma	3 - - -	120 and
	2 - - -	130
In Brussels	1 - - -	125
In Placentia	1 - - -	131
In Faventia	6 - - -	110
	4 - - -	120 and
	1 - - -	132
In Rimino	1 - - -	150

The bills of mortality of the heptarchy of Pinsask, in Russia, contain the following instances of longevity:

5 persons of	110 years of age.
1 - - -	113
4 - - -	120
1 - - -	128
1 - - -	130 and
1 - - -	150

The climate of the British isles is particularly friendly to the human frame, and, in proportion to their population and extent, can produce more instances of longevity than almost any other country of the world. Mr. Carew assures us, that it is no unusual thing for the inhabitants of Cornwall to reach 90 years of age, and at the same time retain their bodily strength and mental faculties. Brown the Cornish beggar lived to 120, and one Polezew to 130 years of age. In Scotland numerous instances of longevity may be quoted from the statistical account of that country. "Within these twenty years," says one of its authors, "at least twelve persons have died in the lower parts of Galloway from 100 to 115 years old." William Marshall, a tinker then living, whose faculties were then unimpaired, and who walked through the country with ease, was 118. In the vicinity of Montrose there were alive, about 1812, five persons between 100 and 110 years of age, eleven betwixt 90 and 100, and forty-eight between 80 and 90. At the same time there were living in the Hebrides, five between 100 and 110, twenty between 90 and 100, fifteen between 80 and 90.

Small islands, and peninsulas, when free from marshes, have been always accounted favourable to long life; and this observation is not confined to particular latitudes. Even in Bermudas, many of the inhabitants reach to a hundred, and some above it; and we are informed, that out of fifteen persons who perished in the dreadful hurricane at Barbadoes in 1780, four were above 100 years old, and one 115. (Easton *on Longevity.*) Madeira has always been distinguished for the salubrity of its climate; and it has been calculated that the expectation of the life of a child newly born in that island is about 39 years, which is more than double of what it is in London. (*Phil. Trans.* vol. lvii. p. 461.) Martin, in his description of the Western Isles, mentions a person in South Uist, aged 130, who retained his appetite and understanding; and one Gilmour M‘Crain, in the isle of Jura, who lived to keep 180 Christmasses in his own house.

The following Table of instances of Longevity is partly extracted from Whitehurt's *Inquiry into the Origin and Strata of the Earth*, with very numerous additions.

Names.	*Age.*	*Residence.*	*Date.*	*Authority.*
Peter Tortin	185	Temeswar, Hungary	A. D. 1724	Kittle's Port. of Old Age.
Gilmour M‘Crain	180	Isle of Jura	——	Martin's Des. of Western Isles.
Louisa Truxo, a Negress	175	Tucomea, S. America	1780	London Chronicle, Oct. 5, 1780.
Henry Jenkins	169	Yorkshire	1670	Phil. Trans. No. 221.
Thomas Parre	152	Shropshire	1635	Ditto, ditto.
James Bowles	152	Killingworth, Warwickshire	1656	
Marcus Aponius	150	Rimino	79	Lord Bacon.
Marc Albuna	150	Ethiopia	——	Hakewell's Ap. lib. 1.
Titus Fullonius	150	Bononia	——	Fulgorus, lib. 8.
Francis Carsist	150	Yorkshire	1768	
Col. Thomas Winslow	146	Ireland	1766	
Christ. J. Drakenberg	146	Norway	1770	Annual Register.
Anne Wignell	146	Jamaica	1812	Edinburgh Annual Register, vol. 5.
Evan Williams	145	Caermarthen	1782	Gen. Gazetteer, Oct. 12.
Countess of Eccleston	143	Ireland	1691	Fuller's Worthies.
Abraham Paiba	142	Charleston, S. Carolina	——	Dittto, ditto.
Simon Sack	141	Trienia	1764	
James Sands	140	Staffordshire	——	Fuller's Worthies.
Countess of Desmond	140	Ireland	——	Raleigh's History.
M. Laurence	140	Shetland	——	Buchanan's History of Scotland.
A. Goldsmith	140	France	1776	Daily Advertiser.
Dumitur Raduly	140	Haromszeck, Transylvania	1782	Gen. Gazetteer.
William Gulstone	140	Ireland	——	Fuller's Worthies.
Galen	140	Pergamus	1271	Vossius' Inst. lib. 3.
Margaret Patton	138	Lochwinnoch	——	Lynche's Guide to Health.
L. Turtulla	137	Arminium	——	Fulgorus, lib. 8.
Margaret Foster	136	Cumberland	1771	
John Mount	136	Scotland	1766	Morning Post.
John Brockey	134	Devonshire	1777	Daily Advertiser.
Richard Lloyd	133	Montgomery	——	Lynche's Guide to Health.

Names.	*Age.*	*Residence.*	*Date.*	*Authority.*
Lucretia Stewart	130	Kingston, Jamaica	1817	Blackwood's Magazine, vol. i. p. 227.
William Ellis	130	Liverpool	1780	London Evening Post.
——— Potezew	130	Cornwall	——	Carew's Survey of Cornwall.
Ermine Diamond	130	Kingston, Jamaica	1812	Edinburgh Annual Register, vol. 5.
Mary Yates	128	Shropshire	1776	Daily Advertiser.
Mary Innes	127	Isle of Skye	1814	Edinburgh Annual Register, vol. 7.
Robert Montgomery	126	Yorkshire	1670	
John Bales	126	Northampton	1766	Inscription in All Saints' Church.
John Tice	125	Worcestershire	1774	Daily Advertiser.
Margaret Scott	125	Dalkeith	---	Inscription on her Tomb, Dalkeith church-yard.
David Ferguson	124	Dunkirk, France	1818	Blackwood's Magazine, vol. iii. p. 738.
Matthew Tait	123	Auchinleck, Ayrshire	1792	Edinburgh Evening Courant.
Edward Conner	122	Taylorstown, Wexford	1815	Edinburgh Annual Register, vol. 8.
Francis Bons	121	France	1769	
John Jacob	121	Mount Jura	1790	All the Public Prints.
Mrs. Sands	120	Staffordshire	——	Fuller's Worthies.
Mr. Dirrane	120	Aaron, Galway, Ireland	1817	Blackwood's Magazine, vol. i. p. 120
—— Brown	120	Cornwall	——	Carew's Survey of Cornwall.
William Postell	120	France	——	Bacon's History, p. 134.
William Marshall	118	Galloway	——	Statistical Account of Scotland.
Cath. M'Kenzie	117	Fowlis, Ross-shire	——	
Cornelius Mudgon	117	Clare, Ireland	1812	Edinburgh Annual Register, vol. 5.
——— Carrol	117	Kilkenny, Ireland	——	Blackwood's Magazine, vol. i. p. 560.
John Urszulach	116	Lemburg, Prussia	1812	Edinburgh Annual Register, vol. 5.
John Wilson	116	Suffolk	1732	General Gazetteer, Oct. 29, 1722.
William Ruthven	116	Avondale, Scotland	1814	Edinburgh Annual Register, vol. 7.
Christian Robertson	115	Glenisla, Scotland	1810	Edinburgh Annual Register, vol. 3.
Patrick Wian	115	Lesbury, Northumberland	——	Plem. Fundam. Med. sect. 4. cap. 8.
Belinda Crawford	115	Galway, Ireland	1812	Edinburgh Annual Register, vol. 5.
Robert Blakeney, Esq.	114	Armagh, Ireland	——	General Gazetteer.
Isabella Sharpe	114	Gateshead	1812	Edinburgh Annual Register, vol. 5.
Ann Rudock	113½	Cornwall	1812	Edinburgh Annual Register, vol. 5.
Mary Harris	113	New Falmouth	1812	Edinburgh Annual Register, vol. 5.
J. Sagar	112	Lancashire	1668	Philosophical Transactions.
James Kayley	112	Middlewich, Cheshire	1781	
William Walker	112	England		
James Beaty	112	Meath, Ireland	1814	Edinburgh Annual Register, vol. 7.
Thomas Gaughan	112	Mayo, Ireland	1814	Edinburgh Annual Register, vol. 7.
Mrs King	111	Dent, Yorkshire	1817	Blackwood's Magazine, vol. i. p. 228.
Cardinal de Sardis	110	Seville, Spain	1785	Easton on Longevity.
Thomas O'Brien	110	Limerick, Ireland	1812	Edinburgh Annual Register, vol. 5.
John Garrow	110	Northumberland	1814	Edinburgh Annual Register, vol. 7.
Edmund Morgan	110	Trawnstynydd, Merionethshire	1817	Blackwood's Magazine, vol. i. p. 120.
Maria Charlotte Cario	109	Hospital of Namur	1818	Blackwood's Magazine, vol. iii. p. 120.
Morgan Crosslet	109	Glamorganshire	1812	Edinburgh Annual Register, vol. 5.
Democritus	109	Abdera	361	Bacon's History.
Janet Taylor	108	Fintray, Scotland	1780	
Charles Craig	108	Dundee, Scotland	1817	Blackwood's Magazine, vol. i. p. 120.
Janet Mulley	108	Crinan, Scotland	1817	Blackwood's Magazine, vol. ii. p. 475.
Catharine Prescott	108	Manchester	1817	Blackwood's Magazine, vol. i. p. 450.
William Gillespie	108	Ruthwell, Scotland	1818	Blackwood's Magazine, vol. iii. p. 494.
Thomas Garrick	108	Fifeshire	1792	
Christiana Howell	107	England	1817	Blackwood's Magazine, vol. i. p. 120.
J. Brown, Esq.	107	Fowlis, Ross-shire	1782	
Marquis of Winchester	106	Hampshire	——	Baker's Chronicle, p. 502.
C. F. Gordon	106	Buckland, near Gosport	1817	Blackwood's Magazine, vol. i. p. 340.
Mrs. Ann Eason	106	Eason Lodge, England	1818	Blackwood's Magazine, vol. iii. p. 494.
James Carrol	106	Kilkenny, Ireland	1817	Blackwood's Magazine, vol. i. p. 560.
Margaret Neyton	106	Liverpool	1815	Edinburgh Annual Register, vol. 8.
William Wilson	106	Edinburgh	1815	Edinburgh Annual Register, vol. 8.
Agnes Milbourne	106	St. Luke's Work-house		
Elizabeth Bell	106	Whitehaven	1813	Edinburgh Annual Register, vol. 6.
M. E. Jeffs	105	Greet, Worcestershire	1812	Edinburgh Annual Register, vol. 5.
Helen Gray	105	Fifeshire	1791	
Lieut. Gen. Mickrelsy	105	Warsovia	1818	Blackwood's Magazine, vol. iii. p. 738.
Jane Robinson	105	Thornton-street, Yorkshire	1817	Blackwood's Magazine, vol. i. p. 560.
Ann Cockbolt	105	Northamptonshire	1775	
John Montgomerie	105	Crookedstone, in Killead	1818	Blackwood's Magazine, No. 20.
J. Bright	105	Ludlow	——	Lynche on Health.
Owen O'Toole	105	Pepperland, Wicklow	1817	Blackwood's Magazine, vol. i. p. 228.
Sarah Codenham	105	Drayton, Norfolk	1815	Edinburgh Annual Register, vol. 8.
Mrs. Isabel Taylor	105	Edinburgh	1818	Blackwood's Magazine, vol. iii. p. 248
Barbary Dodgson	104½	Ferry near Gainsborough	1818	Blackwood's Magazine, No. 20.
Donal Macleod	104	Isle of Sky	1792	His Memoirs.
Alexander Ewart	104	Dumfriesshire	1789	
John Reid	104	Nairn, Scotland	1818	Blackwood's Magazine, vol. iii. p. 248.
Henry Cohen	104	Jews' Hospital, Mile-end	1817	Blackwood's Magazine, vol. i. p. 120.
James Magee	104	Saintfield	1815	Edinburgh Annual Register, vol. 8

Names.	*Age.*	*Residence.*	*Date.*	*Authority.*
Hippocrates	104	Isle of Coos	A. A. C. 358	Lynche on Health, cap. 3.
Lachlan Macquarrie	103	Mull, Scotland	A. D. 1817	Blackwood's Magazine, vol. ii. p. 725.
Jane Reeves	103	Essex	1781	St. James' Chronicle, June 14, 1781.
Lachlan Macbain	102	Edinburgh	1818	Blackwood's Magazine, No. 20.
J. Borrie	102	Little Dunkeld, Scotland	1817	Blackwood's Magazine, vol. i. p. 120.
John Fraser	102	Knockbain, Scotland	1817	Blackwood's Magazine, vol. i. p. 672.
Sarah Foster	102	Coats, near Whittless	1817	Blackwood's Magazine, vol. ii. p. 474.
Catharine Richard	102	England	1818	Blackwood's Magazine, vol. iii. p. 738.
Janet Macfarlane	102	Paisley	1815	Edinburgh Annual Register, vol. 8.
Jane Thompson	102	Dumfries	1815	Edinburgh Annual Register, vol. 8.
John Macbain	101	Gilcomston, Aberdeenshire	1817	Blackwood's Magazine, vol. i. p. 120.
Anne Dinsdale	101	Durham	1817	Blackwood's Magazine, vol. i. p. 450.
Lewis Cornaro	100	Venice	——	Bacon, Hist. of Life, p. 136.
Susannah Hilliar	100	Paddington, Northamptonshire	1781	Northampton Mercury.
Kenneth Munro	100	Kiltearn, Ross-shire	1775	
Countess of Loudoun	100	Loudoun	1779	
Margaret Neil	100	Jedburgh, Scotland	1818	Blackwood's Magazine, vol. iii. p. 247.
John Williams	100	Walkhampton, England	1818	Blackwood's Magazine, vol. iii. p. 494.

For farther information on this subject, see Sir John Sinclair's *Code of Health and Longevity ;* Buchan's *Domestic Medicine ;* Hufeland's *Art of prolonging Life ;* Easton *on Longevity ;* Beddoes' *Manual of Health*, and Cheyne *on Health ;* and Dr. Fothergill's *Observations on Longevity*, in the Manchester Memoirs, vol. i. (*p*)

LONGFORD is the name of an inland county of Ireland, in the northwest of Leinster. It is bounded on the west by the county of Roscommon; on the north by Cavan and Leitrim; and on the east and south by Westmeath. It extends about twenty-five English miles from north to south, and about 24 from east to west, and contains about 366 square miles. It is divided into 23 parishes, 22 of which are in the diocese of Ardagh, united to Tuam.

The northern part of this county consists of rugged mountains, and the south-western part, on the banks of the river Inny, is a bog consisting of about 36,000 English acres, and, therefore, there is but little interesting scenery in the county. The domain of Sir Thomas Newcomen at Carrickglass, which is well planted, and kept in excellent order, forms an exception to the above general character of Longford.

The soil is in general a vegetable mould to the depth of three or four inches, beneath which are two inches of thick blue clay, which retains water, and below this are two or three feet of yellow clay, and lastly limestone gravel. Near Granard there is a fine tract of dry gravelly land, which is employed for fattening cattle. The grain principally raised in Longford is oats, which are sent in great quantities to distant markets.

The principal properties in Kilkenny are the Oxmanstown estate, which is very extensive; that of Sir Thomas Newcomen, worth about 7000*l.* per annum; that of Lord Longford, which rents at 4000*l.*; that of Mr. Edgeworth, which rents at 4500*l.*; and that of Lord Granard, which is worth about 3000*l.* The leases are, in general, for twenty-one years and a life, and the tenures are in general small.

The following were the prices of labour and provisions in 1811:—Wages of a man per day 8d.; grazing a cow per week 4s.; grazing a horse per year 6*l.* 16s. 6d.; Kilkenny coal per cwt. 4s.; potatoes per stone 3d.; butter per lb. 1s.; hay per ton 4*l.* 11s.; beef per lb. 5d.; mutton per lb. 6½d.; eggs in summer per dozen 4d.; cheese per lb. 6d.; fowls per couple 10d.; turkeys 1s. 10d.

Near Lough Gawnagh, in the northern part of the county, a very rich iron ore occurs in solid rocks. Its colour is a dark red, and it breaks into small shelving pieces. In the same part of the county there are indications of coal.

The county of Longford is intersected by the Inny. It is watered also by the Shannon, which forms its western boundary, and which expands into the size of a lake at Lough Reagh. Lough Gawnagh, which covers several acres, is in the north of the county.

The principal manufacture is that of linen. Spinning is universal; and there are now many weavers. There are also some bleaching greens, and great quantities of yarn and hemp are sent to distant markets.

The principal towns are Longford, Granard, Lanesborough, and Edgeworth-town. Longford, which is the shire town, is situated on the river Camlin, and is tolerably large, and pretty well built. It has a charter school for 60 boys. Granard was formerly the residence of the chiefs of North Teffia. Annual prizes have lately been given here to the best performers on the Irish harp. The mole of Granard, the scite of a Danish fort, commands a view of six or seven adjoining counties. Lanesborough is pleasantly situated on the river Shannon, over which there is a bridge leading to Roscommon. Edgeworth-town is a small place, but is deserving of notice, as the residence of the distinguished and amiable family whose name it bears.

The population of Longford has been stated at 10,000 houses, and 50,000 inhabitants. The population of the barony of Granard amounted to 1829 Protestants, and 16,744 Catholics, which gives a population of about 8½ to 1. The Catholic bishop of Ardagh has an income of 300*l.* per annum. About 2000 persons attend mass.

Before the union, Longford sent ten members to Parliament, but it now sends only two. See Beaufort's *Memoir of a Map of Ireland*, and Wakefield's *Statistical Account of Ireland*, passim.

LONGINUS, Dionysius, an eminent Greek author of the third century, was probably an Athenian by birth, though by some he is supposed to have been a native of Syria. His father's name is not known; but by the mother's side he was related to the celebrated Plutarch. In his youth he increased his knowledge, and improved his mind, by travelling to Athens, Rome, and other cities distinguished for literature; where he attended the lectures of all the most eminent masters in eloquence and philosophy. After his travels, he fixed his residence at Athens, where he devoted himself, with the greatest assiduity, to study. Here he published his treatise on the sublime, which raised his reputation, as a critic, to such a height, and gave the Athenians such an exalted idea of his judgment and taste, that they made him sovereign umpire of literature, and every production was received or rejected by the public according to his decision. Such, indeed, was the extent of his erudition, that he was called by his cotemporaries "*the living library.*" He appears to have resided a considerable time at Athens, where he taught the academic philosophy, and had the famous Porphyry among his disciples.

The great reputation for learning which Longinus enjoyed, procured him an invitation to the court of the celebrated Zenobia, queen of Palmyra, who took instructions from him in the Greek language, entrusted him with the education of her sons, and frequently made use of his counsels on political occasions. The distinguished situation which he held at the court of this princess, however, involved him in her subsequent misfortunes. Zenobia was at war with the emperor Aurelian; and having been defeated near Antioch, she was compelled to shut herself up in her capital city, Palmyra. The emperor wrote her a letter, in which he commanded her to surrender; but to this summons the queen returned a spirited answer, supposed to have been drawn up by Longinus, which excited the utmost resentment in the breast of Aurelian. He immediately laid siege to the city, and the inhabitants were, at length, obliged to open their gates and submit to the conqueror. The queen and Longinus attempted to make their escape into Persia; but they were unfortunately overtaken and made prisoners, when on the point of crossing the Euphrates. The intimidated queen had the weakness to attempt to avert the resentment of the emperor, by imputing her resistance to the advice of her ministers and councillors. Longinus was particularly obnoxious; and, without respect to his genius and learning, he was, to the disgrace of Aurelian, ordered for immediate execution. That philosophical spirit, however, which had distinguished him through life, did not desert him in the midst of his misfortunes. He submitted to his fate with a calm and manly fortitude, expressed pity for his unfortunate mistress, and endeavoured to console his afflicted friends. This event took place A. D. 273.

Longinus was the author of a number of philosophical and critical writings. Dr. Pearce has collected the titles of twenty-five treatises which were ascribed to him. Of these numerous writings, however, his *Treatise on the Sublime* is the only one which has escaped the depredations of time; and even this work, upon which the fame of the author now rests, has been handed down to us in a mutilated and imperfect state. But this piece, imperfect as it is, has always been greatly admired for the elevation of its language and sentiments; and although the author's precepts are often obscure, he exhibits a lively sensibility, and an acute perception of the beauties of literary composition.

The most esteemed editions of Longinus are that of Tollius, printed at Utrecht in 1694, *cum notis variorum*, 4to.; of Hudson, Oxford, 1710, 8vo.; of Pearce, London, 1724, 4to.; and of Toup, with the emendations of Ruhnken, Oxford, 1778, 4to. The treatise has been translated into English by Mr. Smith. See Moreri; Brucker; Gibbon; *Gen. Biog. Dict.*; and Harwood's *Classics.*

LONG-ISLAND, is an island belonging to the United States of America, and in the State of New-York. It is 140 miles long, and from 1 to 15 broad; extending from Hudson's river, opposite to Staten-island, nearly to the western boundaries of the coast of Rhode-island. It is separated by Long-island Sound from Connecticut and the county of Westchester; from York-island by the East river; and from Staten-island by the Narrows.

This island is divided into three counties, viz. King's, Queen's, and Suffolk county, of which the following was the population in 1810:

Suffolk county, ...	21,113
Queen's county, ...	19,336
King's county, ...	8,303
Total population, . . .	48,752

In 1790 the population was 41,782, and in 1800 it was 42,097.

Suffolk county is 100 miles long, and 10 broad, and contains one third of the island. It is divided into nine townships, and its inhabitants are almost wholly English. The south part of the county is principally flat land, which is naturally covered with yellow pines. In the north part of the island, a ridge of hills extends from Tamara to South-hold.

Queen's county is 30 miles long, and 12 broad. It contains six townships, and is inhabited partly by Dutch, and partly by English. Hempstead, the most populous of the townships, contains 5803 inhabitants. The western part of this county has been made very productive by husbandry. The eastern part, which forms Hempstead plain, extending 16 miles from west to east, and eight in breadth, is perfectly level, and is covered with wild rank grass, with a few oases, called islands, marked by some stunted trees. This plain produces a little rye, and, together with the salt marshes, it affords food for large herds of cattle. Shrub Oak plain, lying to the south of this, is two miles wide. It is covered with shrub oaks, many of which are 100 years old, and none of them above four feet. There is another shrub oak plain, called Brushy plain, on the eastern part of Hempstead plain, in Suffolk county. It affords shelter to wild deer and grouse.

King's county, forming the west end of the island, is to the west of Queen's county. It is ten miles long, and eight broad. It contains six townships, and is inhabited chiefly by the Dutch. Brooklyn is the principal town. It is fertile and productive.

The eastern extremity of Long-island resembles a shark's mouth. The southern promontory is 20 miles long, and about one wide, terminating in the cape called Montauk Point, on which a lighthouse is erected. The northern promontory, terminating in Oyster-pond Point, is chiefly in the township of South-hold. It is 12 miles long, and very narrow.

The largest river in Long-island is Peconic, or Peakonok, which runs eastward, and empties itself into Great Bay, that separates South-hold from Southampton. This bay contains Robin and Shelter islands. Connecticut river empties itself on the south side of the island. Ronconkama Pond, near the centre of the island, between Smith-town and Islip, is about a mile in circumference, and is observed to rise and fall every seven years. There are two whale fisheries; one from Saggharbour, which yields every year about 1000 barrels of oil, and the other on the south side of the island, which produces from three to seven whales annually, of from 25 to 40 barrels of oil each. A considerable trade is carried on from Saggharbour to the West Indies, in whale oil, pitch, pine boards, horses, cattle, flax seed, beef, &c. The productions of the middle and western parts of the island are carried to New-York. This island was discovered by

Henry Hudson in 1609, and Suffolk county was first settled by emigrants from Lynn in Massachusetts. See Morse's *Modern Geography*, p. 174.

LONGITUDE. See Astronomy.

LONGOMONTANUS, Christian Severinus, a celebrated Danish astronomer, and the friend and assistant of Tycho Brahe, was born in 1562, at Longomontium, a village in Jutland, from which he took his surname. His father being a peasant, his son was compelled to carry on his studies and his rural labour at the same time. When he was 15 years old, he went to Wiborg, and spent 11 years at the college of that place, studying various branches of literature and science, and at the same time gaining a livelihood by manual labour. From Wiborg he went to Copenhagen, and became the assistant of Tycho Brahe, with whom he continued eight years. In 1605, he was appointed professor of mathematics in the university of Copenhagen, an office which he discharged with fidelity and zeal till his death, which happened in 1647, in the 85th year of his age.

His principal work is his *Astronomia Danica*, which appeared in 4to. at Amsterdam in 1622, and afterwards in folio in 1640, and contains the discoveries of Regiomontanus, Purbachius, and Tycho Brahe. It is entitled *Astronomia Donica, in duas partes distributa, quorum prior doctrinam de divina apparente siderum revolutione, super sphæra veterum armillari instaurata, posterior theorias de motibus planetarnm ad observationes Tychonis Brahæ et proprias complectitur, cum appendice de stellis novis et cometis.* In 1639 our author published another work at Copenhagen in 4to. entitled, *Introductio in Theatrum Astronomicum.*

LONGTOWN, is a market town of England, in the county of Cumberland, situated on the great road from Edinburgh to Carlisle. It stands near the borders of Scotland, near the conflux of the rivers Esk and Liddel, over the first of which there is a good stone bridge at the north end of the town. The town consists of one long and two shorter streets, which are regular and spacious, and the houses are built in the modern style, and roofed with slate. The town is situated in the middle of the property of Sir James Graham, Bart. of Netherby. The principal employment of the inhabitants is the weaving of checks for the Carlisle manufactories. The prosperity of this town was greatly owing to the exertions of Sir Robert Graham, the predecessor of Sir James, who constructed the little harbour of Sarkfoot, and thus enabled the people to export their superfluous produce, and supply themselves with the necessary articles of consumption. Population 176 houses, and 1325 inhabitants. See Housman's *Tour in Cumberland*, and the *Beauties of England and Wales*, vol. iii. p. 100.

LOO-CHOO Islands, (called also Lekayo, or Lequeijo, by the Chinese Low-kow, and by some of the natives Doo-choo,) are situated in the sea of Japan, between the parallels of 26° and 27° of North Lat. They are said to be 36 in number, and to have first become known to the Chinese about the year of Christ 605, when a successful expedition was dispatched against them by the emperor Yang-ti, of the dynasty of Souï; but were never properly subjected to the government of China till the year 1372, under the reign of Hong-voo, founder of the dynasty of Ming. The emperor Kang-hi paid more attention to these islands than any of his predecessors had done; and in 1719 sent thither, in quality of ambassador, a learned Chinese, named Supao-quang, who published, on his return, a report on the subject of the Loo-choo isles, of which Pere Gaubil has given some interesting extracts in the 23d vol. of "Lettres Edifiantes et Curieuses." The first European by whom they were visited was Captain Broughton, who was shipwrecked on one of the islands in 1797, on his voyage to the Pacific Ocean; but the most authentic, as well as the fullest information respecting their inhabitants, has been communicated by Captain Basil Hall, of his Majesty's ship Lyra, one of the vessels which accompanied the late embassy to China in 1816. It is chiefly from this gentleman's unassuming but interesting narrative of the voyage in which he was engaged, that the present account of these islands and their inhabitants has been drawn up.

The great Loo-choo island lies between 26° 4½′ and 26° 52½′ of North Lat. and between 127° 34′ and 128° 18′ of East Long. It is about 56 miles in length in a north-east direction, and pretty uniformly 10 or 12 in breadth. Towards the north north-east the coast is very abrupt, and the country altogether barren; the northern extremity is also elevated and bold, but covered with wood to the tops of the hills. The south-east quarter is low, with very little appearance of cultivation; but the west, and south-west and south, present a scene of great fertility and of high cultivation. There are two deep indentures, or bays, one on each side of the island, of which that on the west has about 100 fathoms water, without any appearance of coral rocks; but that on the east is very shallow, and full of reefs. The most remarkable headland is the island on the north-west side, called Sugar Loaf by Captain Broughton, and Egooshcoond by the natives, (*i.e.* tower or castle,) which is a conical mountain covered with houses to one-third of its ascent, and presenting the appearance of a garden. There are two safe anchoring places; Napakiang roads on the south-west, where the Alceste and Lyra lay about a month; and Port Melville on the north-west, a capacious harbour, nearly two miles in length, capable of receiving and sheltering the largest fleet. The island is almost wholly surrounded by coral reefs, through which small openings are found for the admission of vessels. The hills on the north end of the island rise to the height of several hundred feet, and are chiefly composed of grey stratified limestone, without shells; and cliffs of fawn-coloured cellular granular limestone stretch along the whole south and south-west coasts. A great variety of corallines are found in every direction along the shore. The principal mineral productions appear to be sulphur and tin, which form a principal part of the exports to China. The climate appears to be temperate; and the thermometer, during the month of September, stood very uniformly at 82° under a cloudy sky. The barometer indicated little variation, except a slight and sudden descent previous to a gale of wind. Vegetation does not present so luxuriant an appearance on the island, as in countries nearer to the equator; but many of the higher grounds are covered with trees, among which the bamboo holds a conspicuous place, and groves of pines, which grow to a great height and size, are not less frequent.

The cattle are of a black colour, and inferior size, and are used exclusively in the purposes of agriculture. The horses also are small, and of a slender form; but much employed for riding, in which the natives appeared to be fond of exercising themselves. Hogs, goats, and poultry, are sufficiently abundant, but no geese, asses, or sheep, were seen on the island. The coast is frequented by a great variety of beautiful fish.

The agriculture of the island greatly resembles that of China, in the mode of manuring, irrigating, and laying out the fields, which are squared and dressed in the neatest manner, and divided by little banks, or earthen dikes, with narrow walks on the top. The principal objects of cultivation are wheat, rice, Indian corn, millet, sweet potatoes, sugar-cane, tobacco, brinjels, &c.

The manufactures and mechanical arts of the inhabitants are not very extensive; and their tools and implements in general are rather of a diminutive order. They have no carts or wheel carriages. Their saddles are hard and uneven; and their short stirrups are furnished with a box, large enough to admit the whole foot. But they understand the art of building stone arches; and their roads, which are from six to ten feet wide, are kept in an excellent state of repair. They receive their silks and woollens from China; but weave and print cotton cloth with the greatest neatness, and embroider their girdles and pouches with a considerable degree of elegance. They make salt, by sprinkling sea-water upon black sandy earth, spread out thinly on level fields; collecting the earth, after the moisture has been evaporated, into reservoirs of masonry, 6 feet long, 4 wide, and 5 deep; pouring sea-water upon the contents, which carries down the salt as it runs out from a hole below: and reducing this strong brine to cakes of salt, by boiling it in vessels about one foot in depth, and three and a half wide.

Their architecture and accommodations may be appreciated from the following description of a temple and cottage. The former was divided by shifting partitions into four apartments, and had a verandah running entirely round, with a row of carved wooden pillars at the outer edge, to support the roof, which was about ten feet high, and covered with handsome tiles. The cottage was divided into two parts, each 8 feet square, besides a small verandah at one end; the floors made of slips of bamboo, raised about 6 inches above the ground, and covered with straw mats; the walls, 5 feet high, neatly formed by split bamboos wattled together; and the roof covered with thatch, rising to a point. On one side within the house was a set of shelves, with cups and other vessels; and on the other sides were hung implements of husbandry, hats, dresses, all clean and orderly. The fire-place was in the middle of one side, sunk below the level of the floor; and above was a kind of garret, formed by bamboo poles, laid horizontally from the top of the walls, on which were placed various tools, nets, and baskets. Two neat light spinning-wheels stood in the verandah; and a poultry-yard and pigeon-house were adjoining. Each house has its own enclosure; and to some are attached neat arbours of light bamboo frame work, covered with creepers.

Their canoes are mostly made of one piece of wood, and are furnished with two sails. They are impelled with considerable velocity by means of two or more paddles, with an oar over the stern (which acts both as a sculler and rudder,) and a low seat made of rattans for each person. They are sometimes from 12 to 20 feet in length, and from 2 to 4 in breadth; the anchor is made of wood, loaded with stones.

The literature of Loo-choo appears to be very limited; and few books, and those few chiefly Chinese, were seen among the natives. The young men of rank are usually sent to China for education, and the higher classes understand the spoken Chinese language; but the people at large have no knowledge either of the written or spoken language of that country. Their own language is musical, and easy of pronunciation, bearing a near resemblance to that of Japan. A copious vocabulary has been given by Lieutenant J. Clifford, who accompanied Captain Hall.

The government of Loo-choo seems to resemble that of China, and to have not only as much of the form, but much more of the spirit of the patriarchal state. All attempts on the part of the British commanders to visit the sovereign were invariably resisted; and the utmost alarm was manifested upon the slightest appearance of any design on their part to penetrate to the royal residence. It was indeed declared to be contrary to the laws, that any foreigner should approach his presence, except as an ambassador from another monarch. The prince, or the next in succession, however, came once on board the Alceste; when it was observed that the people fell on their knees as he came near them, and that no chief was allowed to sit down or to eat in his presence. The chiefs always gave their orders firmly, but with great mildness, and were obeyed with evident alacrity; nor was any farther punishment ever observed to be inflicted upon an inferior, than an angry look, or a tap with their fan. There are nine orders of mandarins, or public officers, as in China; and their rank is marked, in the same manner, by the bonnet and button which they wear.

The religion of these islanders is that of Buddha, or Fo, and is said to have been introduced about 1000 years ago; but it is a subject about which all classes shewed the greatest indifference, and even seemed to have little knowledge either of its tenets or its forms. The matter is left entirely to the priests, who are treated with no kind of respect, and are nothing more than menials for the service of the temples. They are prohibited to marry, or to taste of animal food, and are objects of ridicule even to the children. In the temples, no objects whatever were observed, except one or two gilt images, about 18 inches high, with a flower in a vase before them, and the picture of a man rescuing a bird from the paw of a cat. Nor was any religious ceremony witnessed, except the killing of a hog, and the burning of some spirits over the grave of a British sailor, who had died on the island; and even this was done solely by the chiefs, without any interference on the part of the priests. Carved stones, called kaw-roo, about two feet long, one broad, and one high, a little excavated on the upper part, with a small portion of rice on the top, were observed in some of the groves; and on these stones were engraved certain figures, denoting the rank of the offerer, besides his petition and its date. Slips of paper, with petitions inscribed on them, were likewise seen in the the temples; but these were addressed as often to the evil as to the good being.

The tombs, like those of China, are in the form of a horse-shoe, 20 or 30 feet long, by 12 or 14 in breadth, built of stone and mortar, and covered with a coat of cheenam, or shell-lime, white washed, and kept always clean. The coffins, when closed, are placed in vaults under these tombs; and after seven years, the bones are collected into jars, which are ranged on the inside of the vaults, or (as these become crowded) are removed to buildings above ground, appropriated for their reception, and sometimes, by the lower people, to caves or hollows in the rocks along the shore.

The natives of Loo-choo are a singularly interesting race. They are rather low in stature, but well formed, and have an easy graceful carriage. The complexion of some is very dark—in others nearly white, but in general of a deep copper colour. Their eyes are black, with a placid expression; their teeth regular, and beautifully white; and their whole countenance full of kindness and intelligence. They are modest in their deportment, timid in their dispositions, polite and respectful in their manners. Their dress is peculiarly graceful, and consists of a thin cotton slip next the body, and a loose flowing robe, with very wide sleeves, tied round the middle by a broad belt, or girdle, of wrought silk. These robes are of various colours and patterns: some striped or printed cottons; some resembling highland tartans; some painted by the hand, instead of being stamped; but the prevailing colour is blue, in all its shades. The girdle is always of a different colour from the gown, and is usually ornamented with flowers in embossed silk; sometimes with gold and silver threads. Their hair, which is of a glossy black, and moistened with the juice of an herb, to make it shine, is shaved off the crown; but this tonsure is concealed by the mode of dressing the hair, which is brought up tight on all sides, and formed into a knot at the top, fastened by two metal pins. Their beards and mustachios are allowed to grow, but are kept neat and clean. The chiefs wear, in fine weather, a yellow cylindrical cap, flat at the top, and formed by winding a broad band diagonally round a frame, so that at each turn a small part of the last fold is visible above in front, and below at the back: the lower orders occasionally tie a coloured cloth, or handkerchief, about the head; they have a neat straw sandal on their feet, over a short cotton stocking, or rather boot, buttoned on the outside, and which has a separate space for the great toe. They all carry fans, which they stick in their girdle, when not in use; and each person has also a short tobacco pipe in a small bag, hanging along with the pouch at the girdle. No ornaments are worn upon their persons, and only in one instance was a ring observed; but, as they speak of the ring-finger, it is supposed that their women may wear rings. In cold weather they have a sort of cloak or great coat, made of thick blue stuff, like woollen cloth, which buttons in front, and is much tighter than their ordinary dress; but they have no idea of gloves.

Their food consists principally of eggs, meat, and vegetables. At an entertainment given to the officers of the Alceste and Lyra, there were presented hard boiled eggs, cut into slices, fish fried in butter, sliced smoked pork, sliced pig's liver, a mess of coarse black sugar, wrapped in unbaked dough, powdered over with rice flour, dyed yellow, (which was not much relished by the Europeans,) round cakes, like gingerbread nuts, and a preparation like cheese, but no milk is ever used. Tea was occasionally handed round, and pipes and tobacco presented between the courses; and a light wine, called sackee, drunk hot out of small cups, is used freely during meals. They seem to be at all times prepared for a repast, and each chief is attended by a boy, generally his son, who carries a little square box, in which are several small drawers, divided into compartments, filled with rice, sliced eggs, small squares of smoked pork, cakes, and fish; and in one corner a small metal pot of sackee, with cups and chop-sticks. In this way they dine when and where they please, inviting one another to join dinners, which they generally take in some cool spot under a tree, sitting in a circle, and emptying their sackee-cups with great sociality. Their manner of living is free, and full of hospitality. In visiting one another, they present a large card, with their name on one corner, and with the words "bows his head and worships." In making an obeisance, they stoop forwards, and raise their hands closed one over the other to the face. They seemed to be fond of the British music and singing; but their own (of which nothing instrumental was observed) was chiefly distinguished by its sweetness and plaintive air. Their dancing, as exhibited by some of the chiefs, consists in standing in a line behind each other, throwing the body into a variety of postures, and twisting the hands about, sometimes placing them flat together, again separate, but generally in the former position; inclining the head slowly from side to side, so as almost to touch the shoulders; moving the feet with a slight and shuffling motion, with an occasional long sweeping step to one side, and then back again in the same manner; making a variety of regular movements, of a waving description; joining in chorus, and clapping the hands; but the perfection of the dance appeared to depend upon the proper use of the hands and body. They were observed at times to wrestle with one another; but nothing was ever noticed which indicated any practice of fighting. Their games are of the simplest description, and obviously associated with a habit of drinking. In one game a person holds the stalk of his tobacco pipe between the palms of his hands, so that the pipe rolls round as he moves his hands, which he holds above his head, so as not to see them; and, after turning it round for a short time, he suddenly stops, when a cup of wine must be drunk by the individual towards whom the bowl of the pipe happens to be directed. In another game, one person holds his hand closed above his head, then brings it quickly down before him with one or more fingers extended, when his antagonist calls out the number of them, and incurs, if wrong, the forfeit of drinking a cup of wine, or, if right, subjects the player to a similar penalty.

No money was seen among them, and they seemed to place no value upon dollars or other coin. They discovered as little wish for foreign commodities, and produced no articles of commerce on their own part. There was no appearance of poverty or distress among them; and no deformed persons, or indication of any disease, except a few individuals marked with the small-pox; but all the population had an air of contentment and happiness. No weapons of any kind were seen on the island; and the natives denied all knowledge of war, either by experience or tradition. Most of them carry knives in their girdles or folds of their garments, but solely for the common purposes of life; and the figures of fish spears in the form of a trident were seen tattooed on the arms of a few persons.

According to the account given by Supao-quang, polygamy prevails at Loo-choo as in China, except that the contracting parties are allowed to see and choose each other before marriage. But it was understood by the British visitants, that no such practice was allowed, and that the sovereign only was permitted to have concubines. The women, however, are, held in a state of great degradation, those of the higher class being much confined to their houses, and those of the lower order employed in the drudgery of field work. They are completely secluded from the sight of strangers; and the men maintained the greatest reserve whenever they were questioned about them. They appeared at a distance to be dressed like the men, except that their garments were shorter, and that they wore no girdle. One lady, who was seen by a female belonging to the British vessels, was fair in complexion, with small dark eyes, and black hair, which was made up into a knot on one side of the head. Great care is taken to form the manners of the children, who are treated with much kindness, and are full of spirit, yet free from any rudeness or disrepectful behaviour.

The character of the people of Loo-choo is extremely amiable and attractive. Their manners are gentle and unassuming, and regulated by the nicest feelings of propriety and politeness. Their dispositions at the same time are social and familiar, full of humanity and friendly attachment. They seemed to be strangers to discord among themselves, and too all avaricious feelings towards their European visitors. Not one article of any kind was stolen or suspected to be stolen, though the natives were admitted freely to the ships, and every thing exposed to their view. Nor did they discover any greediness even for presents, but rather preferred things of little value, especially if they were such as had been worn about the person of the giver. With the exception of their apparent disregard of all religion, their contemptuous treatment of their priests, and their seclusion of the female sex, they might be ranked among the most harmless, though at the same time most feeble and feminine tribes of the human race. But it is not from general description that a just idea can be collected of their unaffected suavity of manners and invariable friendliness of disposition; and we must refer our readers for a livelier picture of their character to the interesting anecdotes related by Captain Hall, and related in a manner which does equal honour to his head and heart. See Grozier's *Description of China*, vol. i.; *Lettres Edifiantes et Curieuses*, vol. xxiii.; Broughton's *Voyage*; M'Leod's *Voyage of His Majesty's Ship Alceste*; and particularly Captain Hall's *Account of a Voyage to the West Coast of Corea and the Great Loo-choo Island*. (*q*)

LOPE DE VEGA. See VEGA.

LORCA, anciently CLIOCRATA, is a town of Spain, in the province of Murcia. It stands at the foot of the Sierra del Cano, a steep schistus mountain on the right bank of the Guadalentin. It is divided into the upper and lower towns. The former of them, occupied by the Moors, is the oldest, and stands entirely on the declivity of the hill. The streets are narrow, crooked, and steep, and the houses are poor and ill-built. The lower, or more modern town, stands almost wholly on level ground. Its streets are long, wide, and even, and several of the houses are grand. It has four gates, and several squares. The lower town has two suburbs, viz. that of Garcia, and that of Christoval, which is large enough to hold 12,000 people. The principal public buildings are the Hotel de Ville, situated in the chief square; the collegiate church, which is a regular building of free stone, with a façade of the Corinthian and Composite orders; the church of the barefoot Carmelites, which is a fine building of elegant architecture; the parish church of St. James', which has a noble appearance; and the church of the Dominicans.

Lorca is governed by a corregidor de roba, and 24 regidors, who form the municipality. It has a collegiate chapter, eight parish churches, seven monasteries, two nunneries, two hospitals, one for males and the other for females, and a college for the education of youth. There is a manufactory of saltpetre at Lorca, but it has no commerce. Silk and kali are exported by the French who have settled in the town.

On the 30th April, 1802, Lorca suffered severely from the bursting of an immense basin of water, constructed of solid materials, which had been collected for the purpose of watering the adjacent territory. Having been undermined at one angle, the basin suddenly gave way, and the water issuing with the most furious impetuosity, swept before it houses, trees, rocks, men, and animals. One of the suburbs of the town, containing about 600 houses, two hospitals, a barrack, two convents, mills, and fountains, were swallowed up, and disappeared in a moment. These ravages extended over a space of 16 leagues. Many villages were destroyed; and even the city of Murcia itself, 12 leagues distant, and the town of Oripuela, 16 leagues distant, suffered in a less degree. The number of people who perished was reckoned at 6000, and the animals at 24,000. The loss was estimated at 200 millions of reals, or 2,083,333*l.* sterling. The population of Lorca is computed at about 30,000; among whom are a great number of nobility, and also a great number of gitanos, or gypsies. See Laborde's *View of Spain*, vol. ii. p. 198.

LORRAINE, CARDINAL. SEE FRANCE.

LORRAINE, CLAUDE, or, more properly, CLAUDE GILLEE. This great painter was born at the village of Chamagne in Lorraine, in 1600. His early life presents little worthy of record, excepting the circumstances of his extreme indigence, supposed stupidity, and total want of education. Nor would these facts be of themselves deserving of notice, were there no instruction to be derived from our being able to mark the remote and obscure point in the general chart of his life, from which he set out in the long and almost solitary journey in the path of art, which conducted him to the lofty eminence on which he stands without a rival. In looking to the commencement and termination of his unexampled career, we are not more surprised and pleased with the instance which it furnishes of that ultimate success, which, in almost every thing to which the human faculties are strongly directed, is, in a greater or less degree, the reward of patient assiduity and unwearied zeal.

At an early age, Claude was put as an apprentice to a pastry-cook; and his biographers have informed us, that after serving his time to this humble vocation, he engaged himself as a valet to some young artists, with whom it was his good fortune to travel to Rome. We find that, soon after his arrival, he entered the service of Agostino Tassi, a landscape painter, and pupil of Paul Brill. Whether accident threw him into these situations, or whether the natural bent of his own mind, longing for some contact, however remote, with the art in which he was destined to flourish, might have influenced his choice in successively entering into the service of persons of this description, we have no direct means of ascertaining; but from the peculiar character of Claude's genius, which, in after life, owed so much to labour and assiduity for its developement, it seems unlikely that, at that early period, either his feelings or anticipations should have been so much alive to the charms and honours of an art of which he must have been profoundly ignorant. To Agostino Tassi he was indebted for some instructions in perspective, and in the art of preparing and using colours. Though at first exceedingly dull of apprehension, he by degrees came to some tolerable measure of expertness in the application of the precepts of his master; and having reached to a certain point of proficiency, his mind seems all at once to have awakened to the use of its native energies. An enthusiastic admiration of nature led him forth to contemplate, amidst the enchanting scenery of Italy, those interesting and delightful changes which characterise the various seasons of the year, and the hours of the day. In an acquaintance with these, and a careful attention to every shifting effect of light and of atmosphere, he found out for himself the great original sources of true knowledge and just feeling in his art. His imagination became vivid, and his judgment learned to discriminate. It is mentioned of Claude, that such was his ardour in endeavouring to improve his taste and skill, that, for many years of his life, the greater part of his time was spent in the open fields, where he was in the habit of remaining from sunrise to sunset, studying and imitating the successive effects which presented themselves to his attention. Those who have surveyed, with due care, the result of these labours, will give full credit to this statement. The fidelity and congruity of his representations, in whatever relates to colouring, to light and shade, and aerial perspective—the magnitude and wide extent of space of which they convey the irresistible impression—the bewitching harmony which unites the numerous parts and features into one pleasing and satisfactory whole—above all, the classic elegance which appears in the choice of his subjects—these are the high qualities which characterise his general style, and which have raised his name to deserved renown. In the works, however, of this immortal man, we must not look for those sublime attributes which belong to some of the other schools of landscape painting, but which are foreign and incompatible with that style of luxuriant and dignified beauty to which Claude devoted his genius. In his chastened and subdued works, we must not hope to find either the wild grandeur of Salvator, the historic air of Dominichino or Titian, nor the simple classic dignity and severity of conception which fills us with respect in the works of Nicolo Poussin. The genius of Claude was, in fact, too much controlled by his devotion to the actual truth of nature, to be always proof against an approach to tameness and insipidity; and certainly was, even in its most inspired moments, ill qualified to venture into the regions of ideal grandeur and sublimity. He had a just eye for viewing nature, taste to select the most beautiful of her aspects; but, beyond what nature points out and authorises, his ambition seems rarely, if ever, to have pointed. One only liberty he appears to have taken, and to that we owe the choicest of his works: we mean his combining into one piece objects which were never combined in actual fact. Thus his landscapes, instead of presenting us with mere views of local scenery, are for the most part compositions made up of the beautiful remains of temples and other ancient buildings, shaded by luxuriant groups of trees, selected and combined by his own judgment; rocks often studied from those about Tivoli, his favourite haunt; and beyond these he delights to introduce a distant view of the Campagna, bounded on the farthest horizon by the sea. Over scenes composed of such materials as these, of which the environs of Rome furnish so rich a choice, the magic and delicate pencil of Claude knew how to throw that soft and vapoury expression of atmosphere, which, when lighted up by the mild effulgence of a rising or a setting sun, constitutes one of those effects of nature, of which it is difficult to say whether it is most allied to the sentiments of beauty or of grandeur. In the middle hours of the day, when the air is free from clouds and vapour, every one must have experienced the uneasy sensation which accompanies the too brilliant glare of sunshine, in which the eye is disturbed, and the attention distracted by a multiplicity of contending lights. On the other hand, all are agreed in admiring that repose and breadth of light and shade, which so often appear under the influence of the morning or evening sun; more especially when accompanied by the thin transparent veil of atmospheric vapour, which half hides and half reveals the beauties of the scene—which, by sinking out of view, or generalising in large masses all the smaller parts which formerly obtruded themselves on the sight, permits the attention to dwell, with undisturbed composure and delight, on the great features of the landscape, thus blended and united into one harmonious whole. When we consider that these are the chosen hours of the day when nature exhibits to us the most pleasing effects, not of light and shade only, but, at the same time, sets out in gorgeous array that wonderful variety of rich and glowing tints, which, when the clouds are in their "thousand liveries dight," shed their warm influence over every part of the landscape, it will not appear strange, that painters should have especially made choice of these appearances as deserving of their best efforts; and that, in our recollection, the name of Claude Lorraine, who of all men seems the most deeply to have caught their inspiration, should stand associated with whatever is most splendidly beautiful in nature, and most pleasing and attractive in art. Whether we consider the grace which appears in the forms and grouping of his fore-ground trees, rich in the ample luxuriance of their foliage, the clearness and cool freshnness of the still waters, which vie with those of nature in reflecting the images of the surrounding objects; his stately buildings, fresh in entire beauty, or mouldering into decay, with their rich fragments scattered around; or whether the eye travels forth over his wide extended plains, diversified by distant cities, and rivers, and towers, and forests, till all is lost and blended in the flood of light which pours down from his radiant skies—in every thing, whether contemplated in detail or in whole, the best works of Claude are calculated to enchant the sense by their delicate and illusive description of the most beautiful objects and select appearances of nature, while, by the associations they awaken, the fancy is stolen away to range in Arcadian scenes and fairy-land. Not less excellence appears in his treatment of marine subjects and sea-ports, of which he executed many. In the latter, he always introduces a great number of figures, actively engaged in the business and bustle which generally characterise such scenes. It is to be lamented that these are, for the most part, indifferently drawn; but we cannot go the length of a late ingenious author, Mr. Gilpin, who, in his indignation against this partial defect, has exclaimed—"perdition sweep them all from our disgusted sight!" The figures of Claude, though ill drawn, serve a most important and essential purpose as points of direct colour; and, for the attainment of this end, they are uniformly well placed in the composition, and introduced with great advantage to the general effect. The fact is, that Claude was generally defective in respect of accurate drawing. This could never be obvious to observation in his trees and grounds, or in any object which, admitting almost every variety of form, is subject to no express rule. But, on a critical examination, this defect is, in many cases, not less observable in his buildings than in his figures. It speaks much in praise of his other excellencies, that they are such as not only to compensate for his faults, but, in general, to hide them from our observation. Although Claude studied with great assiduity at the academy, with the view of obtaining some knowledge of the figure, he was always so much aware of his own deficiency, that he used to say, " that he sold the landscape, but gave away the figures." Accordingly, we find that in many instances, he was in the habit of calling in the occasional aid of other artists for this purpose, particularly that of Courtois and Filippo Lauri.

The works of Claude are very numerous, and many of the most celebrated have found their way into the collections in England. Of this class, in general, are those in the choice collection of Mr. Angerstein, especially the magnificent view of a sea-port, in which is introduced a great variety of figures, representing the embarkation of St. Ursula. In his own time, his pictures sold for large prices; but at the present day, they are held in such estimation as seldom to appear in the market; and, when they do, scarcely any sum is thought too great for them; in various instances, single pictures having brought five, and even seven thousand guineas.

Claude may be considered as the inventor and father of the beautiful and luxuriant style in landscape. He soon attracted numerous followers and imitators, some of whom having attempted, as is still the case, to enrich themselves on the credit of his reputation, by selling their own productions as his, he devised, as a check on such fraud, the plan of his *libra di verita*, in which he made drawings of his pictures, as an authentic record of what he had actually executed. Of this curious collection, six volumes existed at his death; and one of them, containing 200 drawings, is now in the possession of the Duke of Devonshire. They have been well engraved, in the style of the originals, by Mr. Earlom. The beautiful engravings of Woollet and Vivans, after Claude, are well known, and deservedly admired. Of his own hand, there is a number of etchings of landscapes and marine subjects, which, though not executed with much mechanical skill and neatness, are full of character and spirit. He died in 1682, aged 82.

LOSS AND GAIN, is the name given to an operation in practical arithmetic, by which a merchant determines what he has lost or gained on particular transactions. The buying and selling price being first ascertained by Practice or the Rule of Three, the difference between them is the loss or the gain, according as it falls short of, or exceeds the buying price.

LOSTWITHIEL, is a borough and market town of England, in the county of Cornwall. It is situated in a narrow valley, on the west side of the river Fowy, which is navigable to a short distance above the town, and consists chiefly of two narrow and roughly paved streets, running parallel from the river to the base of a steep and lofty hill. The houses are all covered with slate. The only buildings of importance are the church, which has a remarkably handsome spire, and the Stannary prison, which was formerly the residence of the Dukes of Cornwall. The borough is governed by a mayor, six burgesses, and seventeen assistants, chosen annually by the mayor and burgesses. It returns two members to Parliament. The corporation, among other privileges, possesses the anchorage dues of Fowy harbour, and various duties on the salt, corn, and malt, &c. that are brought into that port. There is here a small manufactory of woollen goods. About a mile to the north of Lostwithiel, on the top of a lofty hill, stand the magnificent remains of Restormel Castle. The population of the borough and parish, in 1811, was 132 houses, 178 families, and 825 inhabitants. See the *Beauties of England and Wales*, vol. ii. p. 407.

LOT, the name of one of the southern departments of France, which derives its name from the river Lot, which traverses it. It is bounded on the north by the department of Correze, on the east by the Cantbal, on the south-east by the Aveyron, on the south by the Tarn and the Upper Garonne, on the west by the Lot and Garonne, and on the north-west by the Dordogne. It is 34 leagues long, and 30 broad, and has an area of 376 leagues, or 7552 kilometers. The department is in general hilly, but contains some fertile plains and valleys. The soil is excellent, and its productions are grains, wines, brandy, vitriol, silk, hemp, wool, cattle, iron, coal, and mineral waters. The wines are in high estimation, and those of Cahors particularly fitted for making brandy, of which great quantities are sent to the north of France. The principal rivers are the Lot, the Dordogne, the Aveiron, and the Tarn. The Lot has been rendered navigable from Cahors, by means of sluices. The principal towns are,

	Population.
Cahors, the capital	11,728
Montauban	21,959
Figeac	6,472
Gourdon	3,703

The forests occupy from 73 to 74,000 acres, the greater part of which belongs to individuals. The contributions, in 1802, were 3,235,544 francs, and the expenses 272,533 francs. Population 383,683.

LOT AND GARONNE, formerly *Agenois*, is the name of one of the south-west departments of France, which derives its name from the principal rivers by which it is watered. It is bounded on the north by the department of the Dordogne, on the west by those of the Gironde and the Landes, on the south by those of the Gers and the Upper Garonne, and on the east by that of the Lot. It is 23 leagues long, and 18 broad; and contains 309 square leagues, or 6100 square kilometers. The valleys, which are watered by the Lot and the Garonne, are extremely fertile; but the soil of the Upper Agenois, which forms only about one-eighth of the territory, is much less so. The canton of Villeneuve d'Agen is highly productive. Marmande and Tonneins are distinguished by the tobacco which they manufacture; and the hemp which is raised in both districts supplies numerous rope-works in Marmande. The chief productions are, grains, wines, hemp, brandy, and cattle. The principal rivers are, the Lot, which traverses the department from S. to N. W.; the Garonne, which runs from N. W. to W.; and the Baise, which passes by Nerac. The two first are navigable throughout the department. The following are the chief towns.

	Population.
Agen, the capital	10,820
Marmande	5,598
Nerac	5,587
Villeneuve-d'Agen	5,118

The forests occupy from 48,000 to 49.000 acres, which belong principally to individuals. The contributions, in 1803, were 3,807,413 francs, and the expenses 292,739 francs. Population 352,908.

LOTHAIRE I. See FRANCE.

LOTHAIRE II. See ITALY.

LOTHARIO. See FRANCE.

LOTHIAN, a district in Scotland, which anciently included all the country between the Tweed and the Forth, as far West as the river Avon, and which was long claimed as a part of the English territory. Its name Lodonea, Laudonia, Louthean, or Lothene, is not found in any of the British or Roman records, and may be understood as denoting "a special jurisdiction on the marches," and which is sufficiently appropriate to its history, as a debated frontier tract. When possessed by the British tribes, it formed a part of the territories of the Ottadini, who were obliged to give place to the Saxon invaders in A. D. 450. From this period it was the scene of perpetual contest, and the subject of alternate possession between the Saxon Gaels, or Scoto-Irish; and was at length ceded to Malcolm II. by Eadulf, duke of Northumberland, A. D. 1020. Previous to this period, the whole of ancient Lothian was included in the bishopric of Durham, but was subsequently annexed to that of St. Andrews. Lothian continued to be known as a country distinct from Scotland, even during the reign of David I. but during the reign of William the Lion, the Lammermuir range of hills became the southern boundary of Lothian. The division of the whole into three distinct parts, East, West, and Mid-Lothian, may be dated from the beginning of the 12th century; but, for a considerable time, the shires of Haddington and Linlithgow appear to have been only rated as constabularies under the sheriff of Edinburgh.

LOTHIAN, (EAST,) or HADDINGTONSHIRE, is situated between 55° 46′ 10″ and 56° 3′ 10″ of north latitude, and between 2° 8′ and 2° 49′ of longitude, west from London. It is bounded by Berwickshire on the south and south-east; by the German Ocean on the east; by the Firth of Forth on the north; and by the county of Edinburgh, or Mid-Lothian, on the west and south-west. The rivulet of Dunglass is its southern boundary for about two miles from the east coast; and that of Ravensheugh is its western boundary for about half a mile on the north coast. The length of the county from west to east is about 25 miles, and its breadth from south to north about 18; but, from the irregularity of the sides, it seems to contain a superficies of not more than 297 square miles, or 190,363 English acres.

The county may be divided, in an agricultural view, into four districts. 1st, The coast lands, a stripe of varying breadth, commencing at Ravensheugh burn on the west, and terminating at the eastern extremity of the county, uniformly inclining towards the sea throughout the whole of its extent; 2d, The midland district, comprehending the whole of that ridge, of which the south side leans to the vale of Tyne, and the lands situated immediately to the south of that river, a tract which commences at the western extremity of the county, but terminates a considerable way inland on the east; 3d, The upland district, running along the bottom of the mountainous tract nearly the whole length of the county; and 4th, The mountainous or Lammermuir district, comprehending that extensive range of hills which runs from the south-west along the southern boundary, and terminates at St. Abb's Head.

The climate of East Lothian is extremely various in proportion to its extent; and is considered as peculiarly affected by the elevation of the surface, which rises gradually from the north towards the mountains in separate ridges, running parallel to each other from west to east. In proportion to the altitude of these ridges, the climate is colder, and the seasons later; but the vales correspond nearly with the extensive plain on the east, between North Berwick Law and the Lammermuir hills. The prevailing winds, from December to May, are from the east and north. From the beginning of May to the end of July, the sea breeze from the east usually continues with little interruption, and the weather during this period is generally dry. From the beginning of August to the end of Autumn, the winds are either from the west, or south and south-east, in which last quarter they are commonly attended by rainy or foggy weather; but occasionally during the last-mentioned period, there are high gales from the south-west or north-west, accompanied for the most part with dry weather. The snow seldom remains long in the lower districts; but in the upland parts, and particularly in the Lammermuir district, the ground is frequently covered with it during three months. In the east part of the county, where little rain falls, the harvest in mild seasons is generally ten days earlier than upon the coast lands in the north; and these again are about three or four weeks earlier than the hilly districts.

The county of East Lothian presents a finely diversified surface. From the more elevated part of the Lammermuir district, the view is remarkably rich and beautiful. From the Garleton hills, in the centre of the county, the inequalities of the surface are more discernible, and the various objects brought nearer to the eye of the observer. Spartleton hill, about 1615 feet above the level of the sea, is the highest point in the range of the Lammermuir heights. Traprene Law, a rocky hill, of an oval form, rises singly in an open country to the height of 700 feet above the level of the sea, and affords from its summit a most distinct and extensive prospect. North Berwick Law, a conical hill of a beautiful shape, about half a mile from the sea, is about 800 feet in height; and Down hill, or Dun hill, in the parish of Spot, is about 500 feet above the sea.

The prevailing rocks of this counyt are coal, sandstone, limestone, and marl. The first mentioned substance was dug at Preston-grange, by the monks of Newbottle, so early as the year 1200; at least 90 years before it was known in Fife. Sandstone or freestone is very abundant, and is quarried at Barra, Pencaithland, and Tranent. Iron ore is found in several places; and an iron work is carried on at Fawside, near the last mentioned village. There are mineral springs in the parishes of Humbie, Pencaitland, and Spot, which are much esteemed as remedies for scorbutic disorders; and one has been discovered at Salton House, of the same nature and virtue as the Bristol waters. Scarcely any part of the county is above six miles distant from lime rock.

The principal natural curiosities in the county are the rocky head, on the west side of the harbour of Dunbar, which is composed of red freestone, and on each side bears a great resemblance to the Giant's Causeway in Ireland; and the BASS, which we have already described under that article.

The county is tolerably well watered, except in some of the higher grounds. There are no lakes, and few rivers. The largest is the Tyne, which rises in the moor of Middleton in Edinburghshire, and falls into the Frith of Forth at Tyningham.

Almost every kind of soil known in Great Britian, occurs in East Lothian. The prevailing kinds are a rich loam, a dry gravelly loam, a rich clay, and a thin clay upon a wet bottom. Of the whole county, about 64 parts are arable, 16 are meadow or low lying land, and 20 parts, or one-fifth of the whole, consist of hills and wastes.

In East Lothian there are few druidical remains, and no traces whatever of the Danish name. The prevailing antiquities are the hill forts of the original Celtic inhabitants, and the castles of the feudal ages. Of the former class are the camp in Bolton parish, called Chesters; the circular camp at Garvald, another at Carfrae, and one of great extent on Priestlaw, in Whittingham parish, besides many circular fortlets found almost on every rising ground. Of the latter description are the castle of Dunglass, often mentioned in the Scottish annals as the guard of that pass into North Britain; the castle of Dunbar, which sustained so many formidable attacks, but was at last demolished in 1567, as the residence of the noted Earl of Bothwell; the castle of Dirleton, which arrested the progress of Edward I. in 1298; the castle of Hailes, on the southern banks of the Tyne, which, along with the preceding, was demolished by Cromwell in 1650; the castle of Tamtallon, on a high rock overhanging the sea, two miles east of North Berwick, demolished in 1639; the castle of the Bass (which had sheltered James the infant heir of Robert III. and in the reign of Charles II. was employed as a state prison.) There are also numerous ruins, of whose nature no tradition remains, particularly two beautiful tumuli in the parish of Innerwick, and several in that of Humbie, in which have been found urns containing ashes and bones. On Fidrey isle, in Dirleton parish, is a sacred building, supposed to have been a place of worship, or a hospital; and, on a sandy hillock near North Berwick shore, another, surrounded by a burying ground.

Though Haddingtonshire is mentioned in the charters of David I. who began his reign in the year 1124, yet the term scire, in those grants, meant merely the parish of Haddington. Under Malcolm IV. and his brother William, a certain district round the town is spoken of as under the jurisdiction of a sheriff; but, before the end of the 13th century, it appears to have been made a constabulary, and in 1305 is distinctly stated as subject to the sheriffdom of Edinburgh, in the ordinance of Edward I. for settling the government of Scotland. It is still spoken of under this designation at the period of the restoration of Charles II. but in the first act of James VII. is considered as a distinct shire from that of Edinburgh, and has continued as a separate sheriffdom since the revolution. East Lothian suffered little from foreign or domestic wars till the invasion of Edward I. whose progress was arrested in 1296 by the castle of Dunbar, and in 1298 by that of Dirleton, and the ravages of Edward III. in 1334. It endured the greatest calamities during the revolt of George, Earl of Dunbar, after the year 1400. It was again involved in all the troubles which followed the intrigues of the Duke of Albany, to whom the earldom of Dunbar had been granted in 1455, till the marriage of Lady Margaret of England with James IV. brought east Lothian, as part of her dower, into a nearer connexion with the sovereign.

Baldred, a disciple of Kentigern, is considered as the apostle of East Lothian, who fixed his residence at Tyningham during the sixth century, and converted the Saxon inhabitants of the adjacent country to the Christian faith. From the year 635, to the decline of the Northumbrian kingdom in 1020, the whole country was included in the ample bishopric of Lindisfarn; and from the last mentioned period it formed the deanery of Lothian, under the jurisdiction of the bishop of St. Andrew's, who used to hold episcopal synods anciently at Berwick, but more recently at Haddington, for the government of the clergy. The most celebrated of the religious houses which flourished in those times, were a convent of Cistercian nuns in Haddington, and another of the same sisterhood at North Berwick, upon a commanding height on the south-west side of the town; a monastery of Franciscan friars at Haddington, which is described as a splendid establishment, besides the house of Dominicans, or black friars, in the same town; a house of red or Trinity friars at Dunbar, besides another of Carmelites, or white friars, in the same place. There were also several hospitals in the county, of which the most distinguished, and perhaps the best endowed in Scotland, was the one founded in 1164 at Soutra, by Malclom IV. Besides collegiate churches at Dunbar, Dunglass, Dirleton, Seton, and Botham or Yester, there was at St. German's, an establishment of the Knights Templars, whose revenues, after their suppression, were bestowed on King's College, Aberdeen. Since the Reformation, East Lothian has been distributed into 25 parishes, 15 of which form the presbytery of Haddington, eight that of Dunbar, and the remaining two are connected with that of Dalkeith.

Nearly the whole of the principal estates in E. Lothian are held by charter from the Crown, but some of the smaller proprietors hold of subjects as superiors, for the payment of a trifling quit-rent; and a small part is held of the burghs of Haddington, Dunbar, &c. The valued rent of the county is stated in the records of the Court of Exchequer at L. 168,878, 5s. 10d. Scotch, and the real rent is considered as more than equivalent to the same sum in money sterling. The number of freeholders amounted very recently to 71; and in the year 1800 there were 190 proprietors, ten of whom were noblemen. The estates have, of late years, become larger, and the proprietors fewer; and few counties contain so great a number of gentlemen's seats, some of which, such as the houses of Amisfield, Gosford, and Yesterhouse, are built in a style of princely magnificence. There are three royal burghs, Haddington, Dunbar, and North Berwick, which unite with Jedburgh and Lauder in the election of a representative in Parliament. The population of East Lothian, in 1811, was 31,164.

In agricultural operations and produce, this county holds the first rank in Scotland; and, in the mode of husbandry at least will bear a comparison with the best improved districts of England. From the end of the 11th century, the progress of agriculture was greatly promoted in East Lothian by the kings and barons, and especially by the monks, who pursued, even at that early period, the practice of draining and enclosing. The great number of mills, which existed every where throughout the county, afford some proof of the extent of its agriculture during the 12th and 13th centuries; but the wasteful wars which followed the death of Alexander III. produced the most ruinous consequences in East Lothian; and, notwithstanding all the efforts which were made during the reign of the Bruces and Stewarts to regain the ancient husbandry, it was not till the era of the Union that the spirit of agricultural improvement revived in this county, and before the year 1743 it had become the best cultivated district in Scotland. Among the various improvements of this nature, which seem to have originated in East Lothian, may be mentioned the practice of sowing grass seeds, introduced by the sixth Earl of Haddington; the use of the fanners imported from Holland by Meikle, the mill-wright, under the patronage of Fletcher of Saltoun; the horse-hoeing husbandry by the elder Mr. Wight; the plan of hollowdraining by Patrick Lord Elibank and Sir Hugh Dalrymple; the levelling and straight ening of ridges by two farmers of the name of Cunningham; the culture of turnips by John Marquis of Tweedale, and Sir George Suttie; the planting of potatoes, as a field crop, by Hay, a farmer of Aberlady. Except in the Lammermuir district, and a few parks around the houses of the proprietors, there are no meadows or natural pasture grounds in this county; and except a large common in the upland district, of about 40,000 acres, belonging to the town of Dunbar, there are scarcely any spots that can properly be called waste lands. There are few extensive plantations in the lower districts, and besides those of Tyningham, Newbyth or Broxmouth, and in the higher districts, only one or two old woods, chiefly of oak, which are supposed to be as old as the time of Cromwell's usurpation. Osiers have been cultivated very successfully of late by Mr. Sheriff at Captainhead, who received a gold medal from the society for the encouragement of arts, &c. and whose plan is detailed in the agricultural report of the county. There is nothing in East Lothian that can merit the name of an orchard; and the prevalence of cold easterly winds on its coasts prevent it from being a fruit country. The land appropriated to nurseries and the sale of vegetables is also very inconsiderable, and is situated chiefly in the parishes of Haddington, Dunbar, and Prestonpans. The arable land, independent of what is contained in the Lammermuir or hilly district, amounts to about 120,000 acres, Scotch measure, and of these about 30,000 are moorish soil only occasionally cultivated by the plough. No where are the operations of tillage executed in a stile of greater neatness, or more careful attention paid to the destruction of weeds. The tenantry in general have long been distinguished by their intelligence, activity, and sufficient capital; and have prosecuted the most important improvements at their own expence. Of late years the size of the farms has been considerably increased, some of them being from 500 to 1000 acres, and 200 of good land the average. Some of them yield rents as high as 1500*l.* but the medium is rated at 400*l.* The whole of the lands may be considered as under leases, which now seldom exceed 19 or 21 years, except in a few instances, where the lands require much improvement, which are let for 31 years. There is scarcely an instance in the whole county of a rotation of crops being laid down for the whole lease; but, in a few cases, the proportion of the land to be kept under tillage, and the quantity of each grain to be sown annually, are defined. The farm houses, from being formerly very mean, have, during the last twenty years, been rendered highly commodious and complete; and the cottages have also undergone considerable improvement; but the villages, as a natural consequence of large farms, have fallen into decay. Though enclosures are less material in a corn than a grazing district, the greater part of the farms in this county are enclosed by fences of stone or hedges. In the coast and midland districts wheat is the principal object of culture; and, in four cases out of five, is the article to which the tenant looks for the payment of his rent. The produce in some instances is not less than 14 bolls per acre, and ten bolls are commonly reaped on good lands; but 8 may be considered as the average of the coast and best parts of the midland districts, and 7 of the whole county. Barley is less cultivated than formerly, having given place to wheat, beans, clover, and oats; and where it is sown, the Scotch barley (not the beer or big) is generally preferred. Next to the common oats, (which are now supplanted in the hilly districts by the Dutch and red oats) the Angus and potatoe oats are most generally sown. Peas are not cultivated so extensively as formerly; and flax is raised only for the use of the farmer and his cottars.

Grazing, in nine cases out of ten, is a secondary object, and carried on merely as far as is subservient to tillage. Hence many cattle are fed, but few reared in the county; and almost every person who pursues the sheep farming in the lower districts, (which has rather diminished of late,) buys and sells within the year. In the Lammermuir district, the rearing of sheep, particularly the broked faced species, is regularly practised, and is now carried on in a very systematic manner. Oxen have been rarely employed either in cart or plough for many years in East Lothian. The horses used in the county are generally purchased from the dealers of Ayrshire and Lanarkshire; and are commonly of that middle size which unites activity with strength. Hogs are raised in considerable numbers in this county, principally for the purpose of victualling the ships at Leith and Berwick. Poultry are rather numerous; but pigeons are decreasing in the county. There are not many rabbit warrens, though there is a considerable extent of ground very fit for the purpose; but much of the land which might have been appropriated to these creatures has been rendered capable of bearing tolerable crops of turnips and rye.

The manufacturing arts have not by any means kept pace with those of agriculture in the shire of Haddington, though frequent attempts have been made for their encouragement. A coarse woollen cloth, originally intended for domestic uses, has long been fabricated among the inhabitants, particularly in the county town; and at Athelstonford a variegated kind of stuff, called Gilmerton grey, is made at a moderate price. There is a manufacture of cordage and sail-cloth at Dunbar, but not of great extent, and a few linens have been made at different places. The first bleachfield in Scotland is said to have been established in this county, under the patronage of Cockburn of Ormiston. The first work of that kind, belonging to the British Linen Company, was fixed at Saltoun, under the inspection of Fletcher Lord Milton.

There is a cotton mill in the parish of Dunbar, and a soap manufacture in the town. At Prestonpans there have existed for more than half a century works for pottery, for stoneware, for nitric acid, muriatic acid, &c. There is a manufactory of brown stoneware, and another of glass bottles; at Morison's-haven a considerable tannery; a small manufactory of locks and nails at Tranent; and a paper-mill at Saltoun. A salt work was established at Prestonpans about the end of the 12th century, and along this part of the coast the produce of this article is at least 30,000 bushels yearly. The oyster and herring fisheries were, from a very early period, highly productive.

The foreign trade of this county consisted anciently in the exportation of wool skins and hides, and in the importation of such necessaries as the state of society at that time required. The town of Haddington was for a long time a sort of commercial metropolis, and endeavoured to maintain its traffic from the port of Aberlady, about five miles distant; but its whole shipping consisted at the Revolution of one vessel of 80 tons burden. Dunbar in 1369, North Berwick in 1373, Morison's-haven, or Prestonpans, in 1526, and Cockenzie, or Port Seaton, about the end of the 16th century, became successive rivals to the county town as places of trade. Dunbar and

Prestonpans are the only custom-house ports in the county; and while the shipping of the former, during the forty years which ended in 1800, increased from eight vessels carrying 1135 tons to 16 vessels carrying 1582 tons, those of Prestonpans, during the same period, decreased from 12 vessels carrying 590 tons, to one vessel of 47. The great article of export is grain, of which the county raises, even in the worst seasons, much more than supplies its internal demand, and of which the surplus is carried by land to Edinburgh, or shipped from the ports of Dunbar and North Berwick for London, Grangemouth, and Glasgow. The import trade consists entirely in such commodities as are used within the county, and with which it cannot supply itself; such as iron and timber from the north of Europe, coal from England, Fife, and the coasts of the Forth.

The first turnpike bill for Scotland was an act of Parliament, obtained in 1750 by the gentlemen of this county, for repairing the great post-road from Dunglass to Ravensheugh; and from that period great improvements have been made in the state of the roads.

There is no inland navigation in the county, and no appearance of its being either very urgently required, or easily practicable; while its maritime position renders the carriage to the interior either from the east or the north altogether easy. Canals, however, have been projected; one by the rivulet of Peffer, through an extent of ten miles from Tyningham sands on the east to Aberlady Bay on the west; and another, through a distance only of three miles, from Tynemouth to Linton; but in both cases the benefit likely to arise from them is too trifling to render their formation probable. See LOTHIAN, *West;* Chalmers' *Caledonia; Statistical Account of Scotland;* and *View of the Agriculture of East Lothian for the Board of Agriculture.* (*q*)

LOTHIAN, (MID) or EDINBURGHSHIRE, is bounded on the west by Linlithgow, or West Lothian; on the east by Haddington, and a part of Berwickshire; and on the south by the counties of Selkirk, Peebles, and Lanark. It lies between 55° 39′ 30″, and 55° 59′ 20″ of North Latitude, and between 2° 52′, and 3° 45′ 10″ West Longitude from Greenwich; extending from east to west 38 miles, and 15 from north to south, so as to give a superficies of 358 square miles, or 229,120 English acres.

The area of the county may be considered as mountainous. The most elevated points are the Pentland hills, which commence in Libberton parish, near the centre of the county, and extend about twelve miles in a south-west direction. The highest of these is Eastide Blackhill, towards the middle of the range, which is 1878 feet above the medium level of the sea. The next to the Pentland range are the Moorfoot hills, which form two branches running from Coatland, the one in a north-east direction towards the source of Gala Water, and the other south-east towards the Heriot and Luggate waters. In the parishes of Stow and Heriot, of Ratho, and of Corstorphine, are several smaller hills, besides the three hills on the Water of Leith, called Dalmahoy Craigs, and the extended ridge between the parishes of Crichton and Cranston on the east, and of Cockpen and Dalkeith on the west. Of these secondary heights several are more than 600 feet above the level of the sea. In the immediate vicinity of Edinburgh are the Calton Hill 356 feet, Salisbury Craigs 550, and Arthur's Seat 822, above the medium level of the sea.

Besides the Firth of Forth, which bounds the county on the north, the chief rivers are, the Esk, which receives several streams from the Pentland hills, and, after a course of 22 miles, falls into the Firth at Inveresk; the Water of Leith, which is formed by several streams flowing from Cairn-edge, and which, after running 22 miles in a NE. direction, and driving above 70 mills, passes through the port of Leith; the Almond, which has its source in Lanarkshire, and forms the boundary between West and Mid Lothian, (except in passing through Mid Calder,) till it falls into the Firth of Forth at Cramond; the Gala Water, which, rising in the Moorfoot hills, receives the Heriot and Luggate waters, and, after flowing about ten miles in Edinburghshire, enters the county of Selkirk, and joins its waters with the Tweed.

Mid-Lothian abounds in minerals and fossils. The Pentland hills consist of different kinds of sandstone and secondary trap rocks. A copper mine was opened in 1754, at Lumphoy on Leith Water; ironstone abounds in several places; and freestone of excellent quality is very plentiful throughout the county, particularly at Hailes in Colinton, and at Craigleith in St. Cuthbert's parish. At Pennycuick are found mill-stones, marble, and various petrifactions. Limestone, of which there is supposed to be at least 1,600,000 bushels of lime shells made yearly, is very abundant, particularly towards the hills; and marl has been found in considerable quantities. Pit-coal, which seems to have been used in the county since the beginning of the 13th century, is raised from the numerous veins to the amount of 180,000 tons yearly. Seams of this valuable fuel stretch across the county in a direction from south-west to north-east, 15 miles in length and 8 in breadth. Among the mineral springs may be noticed St. Bernard's Well, on the Water of Leith, in the immediate vicinity of the metropolis; the well of Spa in Cramond parish, which has been found beneficial in scorbutic complaints; several sulphureous springs in Mid Calder, and chalybeate waters in the parish of Pennycuick.

The climate of Mid-Lothian is more temperate than its situation might indicate; and the seasons are more remarkable for their inconstancy than severity. In a course of eight years, from 1795 to 1803 inclusive, the average number of rainy days per annum, in the immediate vicinity of Edinburgh, was 175, and the average depth of rain in inches 25.75.

The soil is greatly diversified; and clay, sand, loam or gravel, are frequently to be seen in the same farm, or even in the same field. It is observable that in this, as in some other counties, the lands hanging towards the north are almost always more fertile, and produce better crops, than those which have a southern exposure. The surface also is very various; but the chief part of the land lies upon a gentle slope to the north or the south in banks, extending from west to east all over the county. Almost the whole extent of it may be seen at once from the summit of Allermore, the most elevated of the Pentland hills to the north. One-third part of the whole may be considered as hilly or unarable; and above two-thirds, or 120,000 Scotch acres, in tillage, pasture, or wood.

There are few monuments of the earliest inhabitants; but some remains of Druidical circles appear in the parish of Kirknewton; and one in Heriot-town hill of high stones, and of considerable extent. There are numerous cairns in the county, particularly in Borthwick parish, on the lands of Currie, and in Collington parish, on the grounds of Comiston. There are several mounds in Mid Calder parish, which appear to be the repositories of the dead; and in the vicinity of Newbottle Abbey there was formerly a large tumulus, surrounded by a circle of stones at the base, and which had a fir-tree growing on its summit. In Pennycuick parish, about ten miles from Edinburgh, there is an oval camp on an eminence, which measures 84 by 67 yards within the enclosure, and contains a number of tumuli. It is surrounded by two ditches, each four yards wide, with a mound of six yards between them. There is a similar encampment in the woods of Pennycuick, on the bank of Harkenburn; and in Borthwick parish, on the farm of Catcune, is a field called the Chesters, in the middle of which is an oval encampment, measuring about half an acre, with an immense round whinstone in its centre, and several cairns at a little distance around it. There are similar, though smaller, remains in the parishes of Crichton, Heriot, Libberton, Lasswade, and Ratho. Mid-Lothian appears to have been a favourite residence of the Roman commanders; and several vestiges of that people are still traced in the county. There is a square camp of considerable size at Sheriff-hall, and another of smaller dimensions on the east side of Newbottle parish. There are vestiges of other posts on the Gore Water in the parish of Currie, and on an eminence at Ravelrig, eight miles south-west from Cramond; but particularly at the mouth of the Almond, where the mole which they had founded on the rock, with altars, coins, medals, pavements, and various remains of their buildings, have been discovered. Roman altars have been found also in the neighbourhood of Currie, and in the church-yard of Borthwick parish. The most remarkable edifices and castles, of late origin, are the Castle of Edinburgh, which, together with that of Roslin, is supposed to have been first occupied by the British tribes, but to have received its name from the Northumbrian prince Edwin about the year 620; the castle of Craigmillar, to the south-east of the metropolis, of the date and origin of which nothing can be ascertained; of Crichton, Borthwick, Dalhousie, Hawthornden, Ravensnook, Brunston, Woodhouselee, Cousland, Catcune, Lockerwart, Fala, and Luggate.

Mid-Lothian appears to have been governed as a shire about the beginning of the 12th century; and its sheriff seems to have had jurisdiction also over the East and West Lothians so late as the end of the 15th century. But the power of the Sheriff of this county was greatly limited by various jurisdictions within his shire, particularly by the Constable of Edinburgh Castle, by the Abbot of Holyrood House, and many baronial courts of regalities, by the justiciary of Lothian, and by the diocesan bishop of St. Andrew's.

The civil history of this county is so completely identified with that of Scotland in general, as to render any separate view of the subject unnecessary, and indeed impracticable within the limits of the present article. It may only be observed, that, from the reign of David II. the county of Mid-Lothian and its capital gradually rose into distinction; and after the assassination of James I. at Perth, became the residence of the court, to whom its castle afforded a secure retreat in those times of turbulence, which no other city, equally calculated for the metropolis of a kingdom, was able to supply. Mid-Lothian, originally under the Bishop of Lindisfarn, and subsequently under the Bishop of St. Andrew's, was afterwards placed under the Bishop of Glasgow, in the character of Official of Lothian. The principal religious institutions were the Abbey of Holyrood, the monastery of Newbottle, founded by the same prince, and occupied by Cistercian monks from Melrose; a convent of Black Friars in Edinburgh, which stood on the site of the present High School; one of Grey Friars, and another of White Friars on the lands of Greenside, at the foot of the Calton, besides nunneries in St. Mary's Wynd, the Pleasance, and the Sciennes. There were also on the Esk a seat of the Knights Templars, and a house of Canons of St. Anthony at Leith; and numerous collegiate churches and hospitals. Mid-Lothian consists at present of 40 parishes, (reckoning the city of Edinburgh as 10,) 22 of which form the presbytery of Edinburgh; 15 that of Dalkeith; 3 in Linlithgow presbytery, and part of Stow, which belongs to that of Lauder.

The population of Mid-Lothian amounted, in 1801, to 124,124; and, in 1811, to 148,607, of whom Edinburgh contains 102,987.

Though Mid-Lothian may be considered as a mountainous county, and was in former times covered with extensive forests, yet more than half of its extent is now employed under tillage or pasturage. The formation of a society of agricultural improvers in Edinburgh in 1723, under the influence of Thomas Hope of Rankeilor, who had learned the practice of farming in England and Flanders, is the true era of enlightened husbandry in this county, and throughout Scotland in general.

The valued rent of the county, as fixed in 1649, is 191,054*l.* 3s. 9d. Scotch money, and the real rent is fast approaching to the same amount in sterling money. Property has undergone many fluctuations of late years; and nearly two-thirds of the extent have been transferred by sale during the course of the last century. Fully one-third of the whole valuation is now strictly entailed. The number of proprietors is about 540, but that of freeholders is only about 130. There is only one royal burgh in the county, namely, the metropolis, which sends one representative to Parliament.

In this county are several hundreds of well-built and ornamented country seats, of which the most magnificent are the Duke of Buccleuch's at Dalkeith, the Marquis of Abercorn's at Duddingston, the Earl of Morton's at Dalmahoy, the Earl of Dalhousie's at Dalhousie-castle, and Lord Somerville's at Somerville-house. The farm-houses are neat and commodious, as in East Lothian, and proportioned to the extent of the farm, so that one year's rent is the usual allowance for the erection of the dwelling-house and offices. The cottages are proportionally improved, generally 16 or 18 feet square, erected at an expence of 15l. or 20l., and rented at 25s. or 30s. per annum. The farms are seldom less than 100 acres, and few of them amount to 300 of arable land. In the vicinity of the metropolis, many hundred acres are let at a high rent as nursery and garden-ground; and lands adjacent to the town are let, even for the purposes of husbandry, at the rate of 5l. or 6l.; but, throughout the county, the rents are much inferior to those in East Lothian. The extent and forms of leases resemble greatly those of the last mentioned county. There are properly no waste or unappropriated lands in Mid-Lothian; but many extensive tracts of poor land, chiefly moss or swamps, employed solely in the pasturing of sheep, amounting to nearly 40,000 acres, of which a great proportion lies in the south-west extremity of the county, from West Calder to the confines of Lanarkshire. About 5000 acres are occupied by natural woods and plantations; the former on the banks of the rivulets, and the latter around the country seats of the proprietors. The ground employed around the metropolis in sale gardens does not exceed 500 acres; but at least 200 acres, chiefly on the banks of the Esk, are devoted to the raising of strawberries, of which about 7000l. worth are sold in a season for the use of the capital. About 200 acres are occupied in nurseries, for which the soil is well adapted, and in which the greatest professional skill is displayed. Generally speaking, the tillage in Mid-Lothian is not performed with much neatness; and in some parts of the moor-lands, the heavy plough, drawn by four horses, is still, or has been very recently, in use. The principal crops are wheat and barley, each of which occupies from 8000 to 10,000 acres; and oats are perhaps still more generally cultivated, both for the food of the inhabitants, and the support of the horses of the metropolis. Beans and pease are generally raised in considerable quantities; but, excepting within five or six miles of Edinburgh, potatoes have not been planted to any great extent. Flax is not extensively cultivated, and very little rye. As the chief object of the cultivators is the production of grain, there is little land left permanently in pasture, perhaps not above 15,000 acres in the county, exclusive of the hills, which are equal to one-third of the whole.

It is but of late years that any attention has been paid in this county to the rearing of live stock, and there is no breed peculiar to the district; but the keeping of milch cows is, of course, much practised in the vicinity of Edinburgh. The sheep in the hilly districts are a small coarse-woolled kind; but a better breed, chiefly of the Cheviot and Bakewell species, have been introduced into the lower districts. The horses, of which above 5000 are employed in husbandry, are chiefly purchased from the adjoining western counties; but the farmers of Mid-Lothian are applying their attention, of late, to the rearing of at least as many as may supply their own purposes. In few places, except in the distilleries, are hogs bred to any extent; and these are chiefly salted and sent to the English market. There are no lands almost adapted for rabbit-warrens; but poultry are raised in great quantities, excepting geese, which, being in demand only at particular seasons, are chiefly procured from Northumberland about the end of autumn, and fattened in the corn stubbles. There are about 300 pigeon-houses in the county; and a great number of hives of bees are kept.

The principal manufactures and commerce of this county are confined to Edinburgh and Leith; and to the accounts of these towns our readers are referred. There are, besides, iron-works at Cramond, paper-mills at Currie, Lasswade, and Pennycuick; brick-works and potteries at Cranston; tanneries, soap-works and candle-works at Dalkeith; cloth manufactories at Inveresk and Stow; and several distilleries in different parts of the county. See LOTHIAN, *West*; Chalmers' *Caledonia*; *Statistical Account of Scotland*; and Robertson's *Agricultural Survey of Mid-Lothian*; and our articles ARTHUR's Seat, EDINBURGH, and LEITH. (*g*)

LOTHIAN, WEST, or LINLITHGOWSHIRE, bounded by the Forth on the north, by Mid-Lothian on the east and south-east, by Lanarkshire on the south-west, and by Stirlingshire on the west. It is separated from Mid-Lothian by the rivers Breich and Almond, except at one point in Mid-Calder; and from Stirlingshire by the Linnburn and the Avon. It is about 22 miles in length along its east boundary, and 14 in breadth along the shore of the Firth of Forth, giving a superficies of 121 square miles, or 77,440 statute acres. The surface of West Lothian is diversified by a number of small hills, a range of which runs from Bowden across the middle of the county, in an oblique direction from north-west to south-east. The highest of these are Cairnpaple, in the centre, about 1498 feet above the level of the sea; and Cocklerne, in the west, about 500 feet. Along the Firth of Forth, the more remarkable eminences are Craigie-hill and Dundas-hill in Dalmeny parish, Craigton-hill and Binns-hill in Abercorn parish, and Irongarth in Linlithgow parish. Most of the hills in the county are as useful as ornamental, affording fine pasturage, and bearing thriving woods. The southern districts consist chiefly of moor and morass, with few eminences. There are no large rivers in West Lothian; but it is well watered by several streams, besides the Almond, which divides it from Edinburgh, and the Avon, which separates it from Stirlingshire. There are mineral springs in Torphichen parish, one of a chalybeate and another of a sulphureous nature; one at Carriden-house, and another near the church of Ecclesmachan, both of which resemble the Moffat waters; and one at Borrowstounness, which exhibits a mixture of sulphur and salts. There is a loch at Linlithgow which covers about 154 acres, and contains pike, perch, and eels; and another called Lochcoat, in Torphichen parish, covering about 22 acres, and containing the same kinds of fish.

The prevailing rock of the county is freestone of the finest quality; and trap or whin-stone rocks are found in most parts. On Dundas-hill, particularly, there is a rock about 60 feet high, and 750 in length, with an almost perpendicular front, the whole of which is a fine green stone. Limestone is very abundant, and is manufactured in many places with great profit. Pit-coal, which is supposed to have been dug in the parish of Borrowstounness above 500 years ago, exists in almost every part of the county, and is raised in great quantities, to the extent at least of 38,000 tons annually. Both shell and stone-marl, but chiefly the former, are found in various quarters, besides fuller's earth, potter's clay, brick clay, and red chalk. Iron-stone is found in considerable abundance in the parishes of Borrowstounness, Torphichen, Bathgate, and Abercorn, and is occasionally wrought and sold to the Carron Company. Silver and lead mines were formerly wrought in the neighbourhood of Linlithgow; and a vein of silver was discovered within a limestone rock in Bathgate parish, but not uniformly rich to pay the expence of working it. Small pieces of money, named groats, were formerly coined from the silver obtained in these mines, during the residence of the kings of Scotland in the palace of Linlithgow.

As the county of West Lothian is tolerably level, and bordered on the north by the waters of the Firth of Forth, its climate is more temperate, both in respect of heat and cold, than might otherwise be concluded from its latitude. It is only in the south-west, where the surface is more elevated, that the climate is rather cold and damp; but, in two-thirds of the county, towards the north and east, the climate, if not the first, is accounted the second in point of mildness in the northern part of the island.

The soil is extremely diversified, containing the richest coarse clay, and best loams, as well as gravelly sandy bottoms; but the most prevailing soil is clay of various qualities. About a fifth part is thin wet soil, or high rocky ground, incapable of cultivation. But the other four-fifths are either in tillage, pasture, or woods.

There are several remains of the original British inhabitants still visible in the county, particularly a large cairn of stones upon Lochcoat Hill, and another on the banks of the Forth about a mile west from Barnbugle Castle. Near Kirkliston, there is a circular earthen tumulus, surrounded by large rough stones at some distance from each other; and some sepulchral tumuli on the south bank of the Almond, opposite to Livingston House. There are stones of ancient appearance in the Wood of Abercorn, near Bathgate; and several druidical monuments at Kipp's House in Torphichen parish. On Cocklerne Hill, Bowden Hill, and Cairnpaple Hill, and an eminence above Ochiltree-Mill, are the vestiges of early forts. The course of the wall built by Lollius Urbicus from the Clyde to the Forth at Carriden, may still be traced from its entrance into this county at Bank End to the House of Grange; and the remains of a Roman Road along the shore of the Forth plainly appear in Ecklin Moor; as also those of a small Roman camp at a windmill near Abercorn.

Linlithgow is supposed to have been formed into a shire as early as the reign of David I. and is noticed as governed by a sheriff in the time of Malcolm IV.; but, as formerly mentioned, was placed by Edward I. in 1305, along with Haddington and Edinburgh, under one sheriff. From the accession of Robert I. till the reign of James III. it appears only as a constabulary; and a number of regalities and baronies existed within the limits of the county. Besides the county town of Linlithgow, there are, in this shire, Queensferry, a royal burgh of recent date; Borrowstounness, a small but busy sea port, and a burgh of regality; Bathgate and Whitburn, burghs of barony; and Blackburn and Brocksburn, small market towns. Among the ancient places of strength in this county may be noticed the Peel of Linlithgow, one of the oldest castles; Blackness Castle, on a promontory projecting into the Forth, which was long a royal fortress; Barnbugle, Kinneil, and Livingstone castles; Niddrie, Torphichen, and Mannerston, with many others now in ruins.

The shire of West Lothian was comprehended within the extensive bishopric of Lindisfarn, during its subjection to the Northumbrian monarchy; but, upon its cession to the Scottish princes, it formed a deanery under the jurisdiction of the still more extended episcopate of St. Andrew's. In 1633, its churches were placed as to spirituals under the bishop of Edinburgh. There were monasteries of Carmelites and Dominicans at Linlithgow; another of Carmelites near Queensferry, the remains of which are still discernible, and the church particularly is almost entire. The order of St. John, or Knights Templars, had their principal seat at Torphichen; and some Gothic ruins near the village are still visible. The county of West Lothian was originally divided at the Reformation into nineteen parishes, which have now been reduced to thirteen, which compose the presbytery of Linlithgow.

The population of West Lothian appears to have suffered little alteration from the year 1755 to 1801, having increased little more than 1500 during all that period; and amounting, at the last mentioned date, to 17,814. In 1811, the population was 19,451.

There is only one royal burgh in the county, which is united with Selkirk, Peebles, and Lanark, in the election of a representative in Parliament.

There are about 70 freeholds in the county, but not more than about 40 proprietors. Many of the houses of the proprietors are pleasantly situated on the banks of the Forth, of which the most distinguished for situation and appearance is Hopetoun House.

Though the farm-houses are much improved, yet there are many in this county on the old plan of one storey. The size of farms is from 50 to 600 acres, but the greater part between 70 and 200. The leases of corn farms seldom exceed 19 or 21 years, although there are a few instances at 24, 38, and even 57 years; but grass farms are usually let on leases of two or three years.

As in the adjoining counties, the real area of agricultural improvements in Linlithgowshire may be dated from the year 1723; and one of the first promoters of its husbandry was John, Earl of Stair, who took up his residence at New Liston in 1728, where he first introduced the practice of horse-hoeing, the culture of artificial grass, and other green crops. Charles, the first Earl of Hopetoun, followed the same example; and after their death, about 30 years, considerable improvements were introduced by a number of practical farmers, who took lands for the purpose of re-letting them to others for an adequate profit, after having brought them into a productive state.

There are above 1000 acres of moss, or more, in the county, of little value, and scarcely capable of amelioration. At a remote period, the greater part of the lands were covered with wood; and not less than 4000 acres are at present under plantations. Above 50,000 acres are well enclosed with various kinds of fences, chiefly of stone. The kind of crops and their produce resembles so very nearly those of Mid-Lothian, that a separate statement is not necessary; and the live stock is almost equally similar in the one county to that of the other, except that a greater number of cattle is now reared in the upland districts of West Lothian than formerly, and that more horses are bred than the county requires.

Various lines of inland navigation had been proposed at different times, to connect the metroplis of Scotland with the great manufacturing city of Glasgow, without success. At last, however, an act of Parliament received the royal assent on the 27th of June, 1817, authorising subscribers, under the title of *The Edinburgh and Glasgow Union Canal Company*, to raise 240,500*l.* in 50*l.* shares, to make a canal in the line surveyed by Mr. Baird, engineer, from Edinburgh, to join the Forth and Clyde Navigation above the sixteenth lock, near Falkirk.

The Union Canal commences at the Lothian road, in the south-western extremity of Edinburgh, and proceeds westward in *one level* by Slateford and Ratho to Linn Mill, where it crosses the river Almond on a large stone aqueduct, and enters the county of West Lothian, or Linlithgowshire. Leaving the Almond, the canal makes a considerable detour by Broxbourn, Winchburgh, Craigton, and Linlithgow, to the dam of Emanuel Mill, a distance of nearly 24 miles, where it passes over the river Avon on a magnificent stone aqueduct, and enters the county of Stirling. From this aqueduct the canal continues westward in the same level by Muiravonside Church and Redding, to the south side of Falkirk moor, where it passes through a narrow ridge to the west of Callendar Park, by a short tunnel about one-third of a mile in length, and thence skirts the northern side of the same ridge, to the grounds of Colonel Duncan of Glenfuir, where it is now proposed to descend 110 feet by nine locks, to the level of the pond above the sixteenth lock of the Forth and Clyde Canal. The summit level of the Union Canal, between Edinburgh and the top of the locks at Glenfuir, is about 30 miles; and the locks, together with the short level below them, about half a mile; making the whole length about 30½ miles.

The Forth and Clyde Navigation rises about 28 feet by 4 locks in the course of 6 miles, from lock sixteen to the summit level at Wineford, from which it stretches 18½ miles in *one level*, to Port Dundas, in the immediate vicinity of Glasgow: thus making the inland navigation between Edinburgh and Glasgow by these two canals about 55 miles.

The execution of the earth work on the Union Canal is considerably advanced, but the large works of masonry are not begun. Of the latter kind in the Lothians, are the stone aqueducts over the Leith, below Slateford, the Almond at Linn Mill, and the Avon above the dam of Emanuel Mill; of which the last is 810 feet long, and varies in height from 75 to 90 feet. The ordinary breadth of the canal is 27 feet top-water, 22 bottom, and 5 feet deep, calculated for boats of 30 tons burden.

The completion of this inland navigation, by locking it down to the sea-port, is an object of great importance to the city of Edinburgh; and we fear neither the company nor the public will derive the full benefit of the Union Canal, until it be carried down to the harbour of Leith. See our articles STIRLINGSHIRE and NAVIGATION *Inland*.

Soon after the passing of the act for executing the Union Canal, Mr. Jardine, engineer, made a general survey of a line of canal, in the latter end of summer 1817, to convey the coal, lime, stone, grain, &c. of the eastern districts of the Lothians to Edinburgh.

The lime commences in a large basin at the eastern extremity of the Meadow, and proceeds nearly straight south, crossing Braid Burn above Libberton-Dams, whence it turns eastward by Greenend to Craigover, and thence sweeping round the grounds of Edmonstone and Wolmet, passes near Newton church, and crosses the North Esk river below Eldinhaugh bridge; from which the line running southward by Eldin colliery and Dalhousie Mains, crosses the South Esk above Newbottle bridge. The line now stretches north-eastward by the eastern side of Newbottle Park and St. Clement's Wells to Tranent, and thence eastward to Haddington; from which, if necessary, it may be continued by Hailes Castle to Berwickshire. Instead of carrying the canal by St. Clement's Wells and Tranent, it may be conducted by Chalkyside and Ormiston to Haddington.

The proposed line of canal above described is all in *one level*, without a single lock, and likewise possesses the great advantage of being in the *same level* with the Union Canal, without interfering with any park or pleasure-ground in its course.

A level branch from the main trunk of the canal passes up the right bank of the South Esk through a short tunnel, avoiding Dalhousie Park, to the dam of Kirkhill spinning-mill, where it terminates at a basin in the level of the river. There is an excellent situation at Tockside, mostly on waste ground, for a large reservoir, amply sufficient both to supply the canal and increase the power of the mills on the South Esk.

The distance by the line of the canal from the basin at the Meadow to Gallowshall tool-bar, where a basin might be made for the trade of Dalkeith, is about six miles and a half; Newbottle bridge eight miles; and about nine miles and a half to the road leading from Dalkeith to Cranston church.

Since the canal terminates in the general level of the streets of Edinburgh, most of the coal, lime, &c. carried to it must be brought somewhere to this general level. Perhaps the best situations for effecting this purpose at the least expence, either by horses or machinery, will be found at the collieries. In many cases, the coals might be raised to the canal with great advantage, on an inclined plane, by two water-waggons: one waggon being filled with water from the canal, a stream, or a reservoir, in descending along with an empty coal-waggon, would draw up a loaded coal-waggon and the empty water-waggon. Were the coal-waggons made water tight, the descending waggon, filled with water, would draw up the other loaded with coal, and thus dispense with the two water-waggons. Indeed, this mode might often be applied with advantage to the inclined planes of railways.

With regard to those portions of the coal-fields which are above the canal, such as those belonging to the Duke of Buccleuch and Queensberry, the Marquis of Lothian, the Lord Chief Baron, the Earl of Roseberry, the Earl of Dalhousie, &c. level-drifts may be made from it to the wall-faces, and the coal wrought like the late Duke of Bridgewater's at Worsley, where there are about twenty miles of subterraneous canal! It may also be observed, that those who wish to carry their coals unbroken to the market, may fill tuns or other boxes at the colliery, and convey them on trams to the boats, which, when loaded with a sufficient number of the boxes, may be tracked in the usual way to the basin at Edinburgh, and each box raised out of the boat by a crane, and set on shafts attached to a pair of wheels, and conveyed along the streets to any part of the town. This mode is practised with success in Derbyshire.

Were the Union Canal carried forward, as originally proposed, to the basin at the eastern end of the Meadow, and a canal from this basin, common to both, locked down by St. Leonard's, Milton house, and the Easter Road, to the harbour of Leith, the inland navigation between Leith, the Lothians, Edinburgh and Glasgow, would be rendered complete.

The first railway in the Lothians, so far as we have observed, was made by Mr. Cadell of Cockenzie, from his colliery near Tranent, in East Rothian, to his salt-works at Port-Seaton. It is about two miles long, and was constructed of woodon rails, but of late most of them have been replaced by others of cast-iron.

In the year 1814, Sir John Hope, Bart. of Craighall, laid a cast-iron single railway, with passing places, from his colliery at Pinkie Burn round Muselburgh, and through Fisher-row, to the depot at Magdalene bridge, a distance of two miles. The first third of a mile from Pinkie Burn *descends* nearly one in seventy, and the second third is nearly level; but the next third, terminating at the railway bridge over the Esk, *rises* one in 700; the remaining mile is nearly level. An ordinary horse draws four waggons along this railway, each containing one ton and a half of coal, and makes five trips per day. Each waggon weighs about twelve hundred weight.

Were this railway continued along the shore on either side of Portobello to Fillysidebank, and thence up the vale of the river Tumble to the Regent Road, and a branch continued from Fillysidebank along the side of the road to Leith, they would perhaps be the most suitable for conveying the coal of the mouth of the Esk to Edinburgh and Leith. We must confess, however, that we do not set much value on the latter, as it does not seem to us probable that Leith will ever become a station for the export of coal.

In summer 1818, Mr. Laing of Newton, tacksman of Edmonstone colliery, made a cast-iron single railway, with passing places, at his own expence, from the coal pits at Newton, round by Howdean and Wisp, to Little France, a distance of nearly four miles. The first furlong next the colliery *descends* about 1 in 125; but the last mile, next Little France, *rises* nearly 1 in 240—the rest is nearly level. A good horse draws four waggons upon this railway, each loaded with one ton and a half of coal, and makes three trips in one day of 10 hours. Each waggon weighs about 14 hundred weight. The spirited undertaking has already proved very advantageous to its owners.

The railways above mentioned are very creditable to the exertions of their authors; but a combined effort is necessary to enable the coal owners of the less expensive winnings in the county of Edinburgh to compete with those on the banks of the Union Canal in the shires of Linlithgow and Stirling.

About the year 1808, the late John Taylor, writer to the signet, with the aid of a professional gentleman, made a general survey of a public railway from the collieries in Mid-Lothian to Edinburgh; but his death took place soon after, and prevented the scheme from coming to maturity. It likewise appears from a printed report on the proposed "Edinburgh Railway," by our friend Mr. Stevenson, engineer, with a copy of which he has kindly favoured us, that he proposed a railway for the same purpose, in the year 1812, to Sir William Rae, Bart. and the Hon. Baron Clerk; but it should seem the proposal met with little or no attention, until the summer of 1817, when the Union Canal Act obtained the sanction of the legislature. This roused the dormant energies of the Mid-Lothian coal owners, who held a public meeting in this city on the 3d of September in the same year, and appointed Mr. Stevenson to make a survey and report of a railway to convey the coal of the county to Edinburgh.

After describing a variety of lines, he ultimately prefers the one which commences at Restalrig Meadow, on the north-eastern side of the Regent Road, and runs eastward to Wheatfield, and then turns south to near Duddingston Mill, whence it stretches south-eastward to the flint mill above Magdalene Bridge, and thence winding by Whitehill, Stonnybank, and Monktonhall, it crosses the Esk at Cowpits, and stretches up the eastern side of Dalkeith Park, crossing the South Esk at Gibraltar to Dalkeith. This line rises about 1 in 720 from Restalrig Meadow to Stonnybank, and nearly 1 in 164 from Cowpits to Dalkeith. The length of the main line from Restalrig Meadow to Dalkeith, is eight miles and a half; and the branch from Wheatfield descending to Leith, is about two miles and a half. The estimated expense of the main line is 41,660*l.*, and the branch to Leith 6,476*l.*, making together 48,136*l.* See RAILWAY; Chalmers' *Caledonia*; *Statistical Account of Scotland*; and Trotter's *Agricultural Survey of West-Lothian.* (*q*)

LOTTERY, strictly speaking, is any kind of game of hazard, in which money, or merchandise of any kind, is deposited, as prizes, for the advantage of those who gain the tickets which entitle them to such prizes; but in this country, it is almost exclusively confined to a particular measure of finance, which, by means of a government lottery, adds to the revenue of the country. The republic of Genoa is said to have been the first who employed lotteries for this purpose.

The earliest notice of a public lottery in England occurs in the years 1567 and 1568. The proposals for it were published then, but the drawing did not take place till the year 1569, at the west door of St. Paul's cathedral. The price of the tickets was ten shillings; there were no blanks; the prizes were chiefly plate; and the profits were devoted to repair the harbours and other public works of the kingdom. The next lottery of which we have any record, was granted, in 1612, by James I. for the purpose of carrying on the settlement of Virginia. The Virginia Company were empowered to open lottery-offices in any part of England. The highest prize was 4000 crowns, in plate. The sum thus raised was 29,000*l.* Soon afterwards, the evils attendant upon lotteries became so apparent, that they attracted the attention of the House of Commons; and, on their representation of them as a grievance, they were suppressed by an order in council. The suppression, however, did not continue long, for, in 1630, Charles I. granted to a company, who undertook to supply London with water, a special license to erect a lottery, and this is the earliest notice of lotteries, either in the *Fœdera* or the *Statute Book.*

Within a year after the Restoration, Charles II. granted a lottery for the support of the Royal Fishery Company of Great Britain and Ireland. The next notice that occurs respecting them is in the year 1695, when private ones had become extremely numerous all over the kingdom—some for money, and some for merchandize; by means of the last, vast quantities of old and decayed merchandize were put off. The evils of these had increased so rapidly, that, in 1698, an act of Parliament was passed for suppressing them. A penalty of 500*l.* was laid on the proprietors, and 20*l.* on every person who adventured in them; but small lotteries were still carried on, under the denomination of sales of gloves, fans, &c. A clause, therefore, was inserted in an act of the 10th of Queen Anne, whereby a penalty of 500*l.* was inflicted on all who thus attempted to evade the former law. This also was ineffectual, for the adventure now made depended on the drawing of the government lottery; and the buying and selling of tickets was in the state lotteries continued till 1718, when an act was passed prohibiting all undertakings resembling lotteries, &c. under a penalty of 100*l.* over and above all former penalties against private lotteries.

The general plan of the state lotteries during the reign of Queen Anne, was to grant annuities for a fixed period, both to blanks and prizes, but at a different rate. In the year 1710, the lottery consisted of 150,000 tickets, at 10*l.* each: The blanks were entitled to an annuity for thirty-two years of 14s; and the prizes to an annuity for the same period of from 5*l.* to 1000*l.* This was the first lottery for which the Bank of England received the subscriptions for government. In 1712 the plan was changed; the whole of the money advanced for tickets was to be repaid in thirty-two years, with interest at 6 per cent.; and within the same period nearly half a million, with interest at the same rate, was also to be divided, which constituted the prizes of the lottery. This, in fact, was given in addition to interest at 6 per cent.

Sir Robert Walpole introduced a new plan of lottery: The price of the tickets was 10*l.*; the highest prize was 10,000*l.*, and the lowest 20*l.* The value of both blanks and prizes was generally funded; the blanks entitled the holders to 5*l.* or 6*l.* stock in the 3 or 4 per cent. The tickets were divided by the lottery office keepers into shares and chances; for the latter there was no return, if the ticket was drawn a blank; the former entitled the holders to the proportion they had purchased of blanks and prizes. In the year 1753, Parliament granted a lottery to set on foot the British Museum. It was for 300,000*l.* in tickets of 3*l.* each. There were 100,000 tickets; the first 50,000 to determine the fate of the second 50,000: Hence it appears that only 200,000*l.* were paid in prizes, and 10,000*l.* remained for the museum. In the year 1759, the scheme of the public lottery included two prizes of 20,000*l.* each, which had not been the case since the time of Queen Anne.

Soon after George III. came to the throne, the Duke of Grafton introduced a material alteration in the plan of the lotteries. The subscribers to 600,000*l.* (part of the loan of the year) were entitled to 60,000 lottery tickets at 10*l.* each. The holders of the tickets were put in possession of so much 3 per cent. stocks: thus a prize of 10,000*l.* entitled the holder to an income of 300*l.* a year; and a blank, valued at 6*l.* to an annuity of 3s. 7d.; the value of the annuities, of course, fluctuating according to the price of the funds. Soon afterwards, there was another material alteration. The allowance to blanks was discontinued, and the proportion of small prizes was very much increased. In 1769, the mode of paying the prizes was altered. Instead of government annuities, the value was paid in cash. One or two prizes of 20,000*l.* and several of 10,000*l.* were introduced; and the first drawn ticket for several days was entitled to 1000*l.* or more. In 1773, the city of London presented a petition to the House of Commons, praying that lotteries—the pernicious consequences of which they set forth—might be discontinued, especially in time of peace; but it had no effect. In the year 1776, the old plan of paying the prizes in annuities in the three per cents. was revived. In the year 1778, six millions were raised by a loan; and the subscribers of 500*l.* might have four tickets at 10*l.* each in a lottery, by which the further sum of 480,000*l.* was to be raised. At the same time an act of Parliament was passed, enacting that office-keepers, selling shares of tickets which they were not possessed of, should be imprisoned three months, and pay a fine of 500*l.*; that every office-keeper should pay 50*l.* for a licence; to be in force for one year; that no smaller share of a ticket than $\frac{1}{16}$th should be sold; that all shares should be stamped; and all schemes of private lotteries, &c. grafted upon the public lottery, were prohibited. No business was to be transacted at any of the offices after eight in the evening, except on the evening of the Saturday preceding the drawing. In consequence of this act, the number of dealers in lottery tickets was reduced to 51 in all England; whereas, in 1777, there were about 4000 in and about London. Before the passing of this act also, 64th shares were sold in every office; and, in 1777, there was one office which sold 300th shares, at 1s. each. Besides miniature lotteries, with shilling tickets, there were tickets issued by publishers of ladies' pocket-books, &c. by bakers, dealers in potatoes, penny-barbers, &c, promising certain sums to their customers, if their numbers should turn out considerable prizes in the lottery.

So late as the year 1780, insurances and almost every other game upon lotteries were legal; but, in 1782, they were all prohibited, under penalties recoverable before magistrates. In this year also, tickets for the lotteries established by the Parliament of Ireland were permitted to be sold in Great Britain, under the same regulations as were enacted for conducting the British state lotteries. In the year 1785, lotteries were first contracted for, entirely distinct from the loans of the respective years: henceforth they have all been managed in the same manner.

In the year 1787, insurances were made punishable in two modes: either by writ of capias, or under the vagrant law; but the first mode was productive of such bad consequences—scarcely any person being safe from actions brought by common informers—that, in the year 1793, it was enacted that only the attorney-general should sue for penalties. As insurances still continued to be effected, to the ruin of the public morals, and the destruction of many families, the act of 1793 contained several clauses against them. Prior to that period, any person might take down the numbers of the tickets at Cowper's Hall, as they were drawn, any person who could pay for a seat being admitted; the profit from the seats forming part of the revenue of the city of London. Insurances were then carried on every hour. The insurers employed 20 or 30 agents to collect the insurance, during the 42 days that each lottery continued drawing; some in cellars; some at bars of coffee-houses: the plan was to receive a small sum, to return a larger if any given number should be drawn a prize or blank. Any sum might be insured from one to twenty guineas; the price of insurance for a guinea, at the commencement of the drawing, was 8d., and it gradually increased. To remedy the facilities which the insurers derived from their seats in the Hall, the commissioners of stamps directed that an agreement should be made with the city of London to rent the Hall, and by the act of the 33d Geo. III. chap. 62, no person was permitted to take down the numbers of the tickets as drawn, unless the clerks to the managers and directors, or those licensed by the commissioners of the stamps; and those persons were to have proper numerical books, every leaf to be stamped by the commissioners of stamps. By other regulations in the same act, insurance in the lottery was completely prevented.

In the year 1802, the Irish lotteries were abolished; and the English lottery was increased to 100,000 tickets, divided into three or four lotteries, each to be drawn in eight days. In the year 1808, there were two reports of a committee of the House of Commons on the subject of lotteries: the evidence adduced before them unfolded a dreadful scene of misery, vice, and ruin, brought on by means of lotteries; and they strongly recommended their entire abolition, or, if that were not done, that certain regulations which they specified should be adopted. Some of their suggestions were for a time attended to, especially that which advised the drawing of the lottery in one day; but at present the drawing generally continues three or four days, and there are four lotteries in the course of the year.

Having thus given a brief historical sketch of lotteries in this country, we shall conclude this article with considering them as a measure of revenue, and as they affect the contractors and the purchasers. The gross sum received by Government, directly or indirectly, by the lottery, is estimated at about 750,000*l*; that is, about 500,000*l.* as the price of the tickets, and the remainder from postages, stamps, &c.; from this, however, is to be deducted the salaries of the commissioners, &c. and other expences, so that the clear revenue cannot be rated higher than between 500,000*l.* and 600,000*l.* per annum. The general advance put upon tickets by the contractor used to be about 3*l.* per ticket, but now it is generally nearly 5*l.* The expence of the lottery to the contractors is supposed to average about 18,000*l.*; it answers to them, if four-fifths are sold. The lottery-office keeper also puts on a profit, which, in those numbers divided into eighths, sixteenths, &c. amounts to about 1*l.* per ticket: about 50 years ago, tickets were upon an average of the whole multiplied by eight; that is, the aggregate of the whole tickets shared was generally multiplied by eight, to find the number of shares; but now, it must be multiplied by 10 at least, the higher numbers having decreased, and the lower increased. With respect to the purchasers of tickets, let us suppose that the actual value of the tickets is 10*l.*, and that they are sold at 19*l.* it is evident that the adventurers in such a lottery (and such may be considered the average of lotteries in general) gamble at a disadvantage of nearly 100*l.* per cent. (W. S.)

LOUGHBOROUGH is a market town of England, in the county of Leicester. It is situated on a branch of the river Soare, over which there is a good stone bridge; and, on the side of the Loughborough canal, which communicates with the Soare, the town consists of one principal street, forming part of the road from Leicester to Derby, and four smaller ones, by which it is crossed at right angles. Many of the houses have an ancient and irregular appearance, which takes away from the look of the town. The church is a large pile of building. There is also here a grammar school, a charity school for 80 boys and twenty girls, and meeting-houses for the Presbyterian Baptists, Quakers, and Wesleyan Methodists. The principal manufactures of Loughborough are hosiery, wool-combing, and stocking-knitting. The population of the parish, in 1811, was 1218 houses, 1179 families, and 5400 inhabitants.

LOUISBOURG. See BRETON, CAPE.

LOUISIANA, is the name given in honour of Louis XVI. to an extensive country in North America, belonging to the United States. The boundaries of the country have never been satisfactorily determined. On the east it is considered as bounded by the Perdido, a river in West Florida. The Rio Colorado forms its western boundary. On the north it is unlimited, but may be considered as reaching the Winnipec river and lake. The extent of coast, between the mouth of Lake Ponchartrain and that of the Mexicano, is about 280 miles; between the Mexicano and the Perdido 420 miles; between the Perdido and Colorado, 720 miles; and between the Perdido and Bravo 1020 miles.

Louisiana is divided into two governments, the *state of Louisiana*, and the *territory of Louisiana.*

The state of Louisiana comprehends, 1st, The county between the Perdido on the east, the Mississippi on the west, the Ibberville and the Gulf on the south, and the Mississippi territory on the north; 2. The island of Orleans, the name given to the tract between the Mississippi on the S. W. and the Ibberville and lakes Maurepas and Ponchartrain on the N. E. It stretches from E. S. E. to N. N. W. and is about 160 miles long, with a breadth varying from 6 to 25 miles; and 3. All the territory west of the Mississippi, and south of Lat. 33°.

The territory of Louisiana comprehends all the country west of the Mississippi, and north of Lat. 33°.

The state of Louisiana is divided into 5 districts, viz.

			Population.
1st District.	County of Orleans	Parish of Orleans, viz.	32,402
		City & Sub. of N. Orleans	
		Precincts of N. Orleans	
		Parish of Plaquemine	
		——— St. Bernard	
	Germans Coast	——— St. Charles	
		——— St. John Baptist	
2d District.	Acadia	——— St. James	13,320
		——— Ascension	
	La Fourche	——— Assumption	
		——— Interior of La Fourche	
	Ibberville	——— Ibberville	
3d District.		——— Baton Rouge	8,897
	Point Coupée	——— Point Coupée	
	Concordia	——— Concordia	
4th District.	Ouachitta	——— Ouachitta	3,526
	Rapides	——— Rapides	
		——— Catahula	
		——— Avoyelles	
	Natchitoches	——— Natchitoches	
5th Dis	Opelousas	——— Opelousas	12,117
	Atakapas	——— Atakapas	
		Total Population	76,556

The territory of Louisiana is divided in the following manner:

	Population.
District of St. Charles	3505
——— St. Louis	5667
——— St. Geneveive	4620
——— Cape Girardeau	3888
——— New Madrid	2103
Settlements of Hopefield and St. Francis	188
Settlements on the Arkansas	874
	20,845

The bank of the Mississippi, from the bend at the mouth of the Missouri to Cape Girardeau, a distance of 157 miles, is generally high, forming a ridge of moderate elevation; and it has a mountainous appearance from Cape Girardeau to the grand chain of rocks, a distance of 21 miles. Below this chain, the bank is nearly on a level with the river, and in freshes is almost every where overflowed. The country to the west of it, from 20 to 25 miles in breadth, is an immense swamp of more than 40,000 square miles, stretching to the mouth of the river, and annually overflowed during the freshes. The country between this swamp and the Viceroyalty of Mexico consists of vast steppes or savannahs, covered with grass. These steppes are described by Mr. Jefferson as too rich to bear fruit trees, and are covered with a tall rich grass, in which numberless herds of buffalo and deer are lost. The cultivable land near New Orleans is highly fertile, and so is that near the Missouri, and on the western branches of the Mississippi.

A district of country called the Mines, about 50 miles long and 25 broad, contains the celebrated lead mines of Louisiana. This tract begins about 25 or 30 miles west of St. Geneveive. The *Mine le Mott* is the nearest to the Mississippi. The *Mines of Garberie* are 17 miles from the first, the *New Diggings* 13 miles farther; the *Mine* *le Berton*, discovered about 64 years ago, three miles farther; and the *old* mines five miles farther, and 83 from St. Louis. The ore is very rich and abundant in this tract. It sells at 18 or 20 dollars a thousand weight at the works, while the metal brings five dollars a hundred weight. It yields about 80 or 90 per cent. of pure metal. In 1807, about 912 stone were smelted. The whole county contains only one air furnace, which is at Mine le Berton, where an extensive shot manufactory has been established.

Louisiana is not celebrated for its manufactures. The Acadians manufacture a little cotton into quilts and cottonades, and some of the poorer planters in the distant parts of the province spin and weave some negro cloths of cotton and wool mixed. Here is a machine for spinning cotton in the parish of Ibberville, and another in the Opelousas. See New Orleans, for an account of its manufactures.

The productions of Louisiana are sugar, cotton, indigo, rice, furs, peltry, lumber, tar, pitch, flour, horses, cattle, and lead; but of these only cotton, sugar, molasses, and furs, are exported. In the year 1802, 250 sail entered the Mississippi, viz. 170 Americans, 97 Spanish, and 1 French. Their tonnage was 33,725. The vessels which left the Mississippi were 265 in number, viz. 158 Americans, weighing 21,383 tons, 104 Spanish, 9753 tons, and 3 French, 105 tons; the total tonnage being 34,241.

The amount of imports into Louisiana and the Floridas, and of exports to the United States from the same counties, is as follows:

	Imports. Dollars.	*Exports.* Dollars.
1802	1,224,710	1,006,214
1804	2,500,000	2,157,005

From the Port of New Orleans.

1810 . . .	Domestic	1,753,974
	Foreign	136,978
	Total	1,890,952
1811 . . .	Domestic	2,501,842
	Foreign	148,208
	Total	2,650,050

The commerce of this country is greatly facilitated by its inland navigation. The Mississippi, (see that article,) the Red River, the Arkansas, the Ohio, the Missouri, and the Illinois, with their branches, lay open an extent of inland navigation which has no parallel on the globe. The difficulty of ascending the Mississippi has cut off New Orleans from supplying the western states with foreign merchandise; but we have no doubt that the steam vessels have already, in a great measure, removed the evil. The mode in which coasting vessels transport the merchandise to New Orleans, is to ascend Lake Ponchartrain to the mouth of Bayau St. John. The goods are then put into boats, carried up the Bayau six miles, and from thence to the city through the canal of Carondolet, which is two miles long. In 1809, congress appropriated 25,000 dollars for carrying the canal to the Mississippi.

The only town of consequence in Louisiana is New Orleans, an account of which will be found under New Orleans. St. Louis is a village of 200 houses, finely situated on the Mississippi, in West Long. 89° 36′, and North Lat. 38° 18′. The town and its district contain 5667 inhabitants. St. Genevieve is 73 miles below St. Louis, in West Long. 89° 28′, and North Lat. 37° 51′. It is the storehouse of the neighbouring mines, and with its district has a population of 4620. New Madrid is 181 miles below St. Genevieve, in West Long. 89° 28′, and North Lat. 36° 34′. It has suffered greatly from earthquakes. It is the lowest settlement on the west side of the river, and contains, with its district, 2103 inhabitants.

The principal rivers in Louisiana are the Mississippi, Missouri, Ibberville, Perdido, (see Florida,) St. Pierre, De Moines, St. Francis, White River, Arkansas, Red River, Bayau Chafaila, Rio Mexicano, Sabine, and Rio de la Trinidad. For an account of the Mississippi river, see Mississippi. The Missouri, near its source, is formed of three branches, which rise among the rocky mountains, one in lat. 48° north, another in lat. 42° north, and all of them nearly in 122° West Long. The distance through which the Missouri is navigable before it falls into the Mississippi, is said to be 3106 miles, but Morse thinks it only about 2400. As the Missouri branch is much larger than the Mississippi branch, the name of Missouri has been given by some geographers to their united stream. The Ibberville is a bayau or outlet of the Mississippi, beginning 15 miles below Baton Rouge, and 121 above New Orleans. It is navigable three months in the year for boats drawing five feet of water: It is wholly dry for several months. The water of the Mississippi, in the time of freshes, flows through the Ibberville into Lake Maurepas, and thence into Lake Ponchartrain.

The river St. Pierre runs into the Mississippi 10 miles below the falls of St. Anthony. It rises far to the west, and is very large.

The river De Moines runs into the Mississippi between the St. Pierre and the Illinois.

The river St. Francis falls into the Mississippi 508 miles below the Missouri, in Lat. 34° 44′ N. and Long. 90° 29′ W. by a mouth 200 yards wide. It is navigable for more than 200 miles.

The White River falls into the Mississippi 595 miles below the Missouri, and by a mouth 150 yards wide. It is navigable upwards of 100 miles.

The Arkansas, which rises in Mexico, flows into the Mississippi 615 miles below the Missouri, in Lat. 34° 1′ N. and Long. 91° 4′ W. It is navigable for 500 or 600 miles. If it is the same with the Napestle, as Humboldt supposes, its length must be at least 1500 miles.

Red River falls into the Mississippi 1068 miles below the Missouri. It rises in Mexico, and, according to Humboldt, is supposed to be the same as the Rio de Pecos. If this is the case, its length will be upwards of 1200 miles.

The Bayau Chafaila leaves the Mississippi three miles below the mouth of Red River.

The climate of Louisiana below the Ohio is described as very unhealthy, from the number of swamps and marshes. It is more salubrious along the Missouri, and farther north. At New Orleans, the weather is very agreeable in winter, but hot and sultry in summer.

The population of Louisiana, in 1810, was as follows:

State of Louisiana	Whites . .	34,311	54,814
	Free blacks	7,583	
	Slaves . .	12,920	

Territory of Louisiana	Whites . .	17,227	20,845
	Free blacks .	607	
	Slaves . . .	3,011	
	Total		75,659

About two-fifths of the settlers on the Spanish side of the Mississippi are supposed to be Americans. Below New Orleans the population is French.

Louisiana was first discovered in 1541 by Ferdinand de Soto; and in 1682 it received its name from Mons. Salle from Canada, who first traversed the Mississippi. In November, 1762, Louisiana was ceded by France to Spain; but the Spaniards, owing to the resistance of the inhabitants, did not obtain possession of it till 1769. By the treaty of Ildefonso of 1800, Spain ceded Louisiana to France; and from France it passed to the United States in 1803.

The territory of Orleans was made a state in 1811, and the country between the Ibberville and the Perdido was taken possession of in 1811 and 1812. See Humboldt's *Political Essay on the Kingdom of New Spain*; Morse's *System of Geography*, and our articles AMERICA and FLORIDA.

LOUREIRO, JOHN DE. See BOTANY.

LOUTH, anciently *Luda*, a market town of England, in the county of Lincoln, is agreeably situated on the river Ludd and the Louth canal, in a fertile vale, at the east foot of the Wolds. The streets are neat and clean, and many of the houses elegant. The principal public buildings are the church, the town-hall, the mansion-house, or assembly rooms, and the theatre. The church of St. James is a spacious building, and has a very handsome spire, about 288 feet high, which has been greatly admired. The town-hall is an old plain building, at the end of the principal street leading to the market-place. The mansion-house is fitted up in the Grecian style with considerable taste, and the theatre was built by Mr. Blythe, a public-spirited individual, who has contributed greatly to the improvement of the town. There are other three churches, belonging to the Catholics, the Baptists, and the Methodists. There is here also a free grammar school, founded by Edward VI. and a free school for poor boys, both of which are well endowed. The principal manufactures are a carpet and blanket manufactory, a large soap manufactory, and a paper mill. The trade of this place is greatly promoted by the canal, by means of which vessels of considerable burden export quantities of corn and wool, and bring back timber, coals, and groceries. The vicarage house, called the Hermitage, is deserving of being visited. The population of the town and parish, in 1811, was, houses 983, families 1018, and inhabitants 4761. See *Beauties of England and Wales*, vol. ix. p. 695.

LOUTH, a maritime county of Ireland, in the province of Leinster, is bounded on the north by Armagh, on the north-east by the bay of Carlingford, by which it is separated from Down, on the east by the Irish sea, on the south by Meath, and on the west by Meath and Monaghan. Louth is about 27 English miles long, and 18 broad; and is the smallest in Ireland. Its area is about 177,926 acres, or 278 square miles.

Louth is in general a rich and well-cultivated county. Its general aspect is flat, with gentle superficial undulations, excepting in the peninsula between Carlingford and Dundalk bays, and on the confines of Armagh, where it rises into hills of considerable elevation. The greater part of this county is under tillage; and the spirit of agricultural improvement has shewn itself more here than in most other parts of Ireland. This happy effect has been owing chiefly, if not wholly, to the activity and example of the late Lord Chief Baron Forster, and of his son, the Right Hon. John Forster, who, both in his public and private capacities, has been the unceasing promoter of the agricultural prosperity of his country. Mr. Wakefield informs us, that Mr. Kiernan, the agent of Mr. Forster, allows the thistles and ragweed with which his pastures abound to attain their full size, when they are cut and burnt, and the ashes sold. His fallows are ploughed five times; but a roller is never used, shovelling being employed in its stead. He occupies 250 acres, about 20 of which are in fallow; and has about 140 head of cattle. His sheep, which he feeds in winter, and sells in spring, are a mixed breed of the Leicester and South Down. He manured his land with lime, allowing to each acre 100 barrels, each weighing 2½ cwt. at one shilling per barrel. This process, however, is employed only once in 20 years. The rents in the neighbourhood of Collon were then about two guineas per acre. A guinea per acre was paid for ploughing; but it was difficult to get half an acre tilled in this manner in a day. Mr. Wakefield also remarks that the lands of Collon were cold and heavy, and that the fields were large and well divided. The principal crops in the county are wheat, barley, oats, flax, and potatoes; and there is also a good deal of peas and red clover. Louth is not a breeding county; but its breed of cattle is the small stunted one which pervades Ireland. The corn produced in this county finds its way to Drogheda and Dublin; the former of which is the largest corn market in the kingdom. The wheat, however, is sold in general to the different flour mills, which are here numerous.

The principal proprietors of the county are Lord Roden, Mr. Foster, and Lord Fortesque. Besides the town of Dundalk, Lord Roden possesses 6000 acres, 4050 of which are let on determinable leases. Mr. Forster's estate, situated at Collon and Dunleer, is almost as large. That of Lord Fortescue is nearly of the same size. The estates of the other proprietors are worth from 150*l.* to 2000*l.* per annum, and the farms are in general large. The average rent of land is 30 or 31 shillings per acre.

The following were the prices of labour and provisions in 1811. Wages of a man in the year, 15*l.* 15s.; do. of a woman, 10*l.* Grazing a cow per week, 4s. 4d.; do. a horse, 6s. 6d. Kilkenny coal, per cwt. 1s. 6d. Lime, per barrel, 1s. 4d. Hay, per ton, 3*l.* 10s. Beef, per lb. 6d.; mutton, 7d.; veal, 8d. Eggs, per score, 1s. 7d. Fowls, per couple, 10d. Turkeys, each, 1s. 10d. Geese, 1s. 2d.

The mineralogy of this county does not seem to have been much examined. Limestone is found in a small tract in the neighbourhood of Carlingford, and at Castletown, on the confines of Armagh. A fine white shelly marl occurs in great abundance in the bogs under the turf. Some ochres and soap rock have been found; and a lead mine was once wrought at Salters-town, on the sea coast, near Castlebellingham. The prevailing rock is called whinstone, which, according to Sir C. Coote, contains 46 parts of silica, 22 of alumine, 28 oxide of iron, and 4 of lime. The same stone is found in Armagh and Monaghan. In the parish of Creggan, lead is supposed to exist, and there are several slate quarries in it.

The principal river of Louth is the Boyne, which runs through Meath, forming the southern boundary of Louth, about two miles west of Drogheda, and discharges itself into the sea about two miles below that town. The celebrated battle fought at a ford of this river by King William has been commemorated by a magnificent obelisk, which stands near some scenery of great beauty. A wooded plain, through which the victorious army marched, runs down to the place where it crossed the river. It is about nine miles distant from Drogheda, and is bounded on one side by the beautiful domain of Mr. Belfour, and on the other by that of Mr. Codrington.

The principal towns and places in Louth are Dundalk, Drogheda, Carlingford, and Collon. Drogheda has already been described in a separate article. Dundalk is the assize town of the county, and is a sea-port. It consists principally of a wide open street, about a mile long, crossed by several lanes. The harbour is safe and commodious, and though inferior to Drogheda, it exports considerable quantities of corn. The bay has good mooring, and abounds with fish. There is a market-house in the town, and it has a considerable manufacture of muslins, linens, and cambrics. Dundalk is a close borough, of which the Earl of Roden is patron. Carlingford is also a sea-port town. Its castle, said to be built by King John, stands on a solid rock, washed by the sea. The harbour is between three and four miles long, and as many broad; and the largest vessels can anchor in 20 fathoms of water. It is celebrated for its excellent oysters. Large quantities of butter, brought by the canal from the county of Tyrone, are shipped at this port, and it has also a share in the export of the linen manufactured in the neighbourhood. Collon is a village, surrounded by trees, and delightfully situated among hills. In 1810 it consisted of about a hundred neat houses, all white washed. It has a church, with a stone bridge across the river, and a bleaching-green near it. This village has arisen within the last 40 years, principally by the exertions of Mr. Forster, whose estate is at Collon, and who has established in the village a cotton manufactory. "Though there are many other seats in the county," says Mr. Wakefield, "I must in a particular manner call the traveller's attention to this interesting spot, which, in every point of view, is superior to them all. No place in the island is more worthy of notice. By the improvements around, the stranger will perceive, long before he reaches it, the plans of a great and comprehensive mind, executed with much taste and judgment. The roads in the neighbourhood are in as good order as any in Europe." There were no fewer than 1300 looms employed in calico weaving, by two persons in the neighbourhood of Collon. The cloth is chiefly 7-8ths wide.

Louth sends one member to Parliament, chiefly by the influence of Lord Roden and Mr. Forster. Its population was a long time ago estimated at 57,750. The proportion of Catholics to Protestants is estimated at 15 to 1. Collon is considered the most Protestant parish in the county. The church is attended by about 130 persons, and the Catholic chapel by about 1000. There is also a Methodist meeting-house in the village.

The principal manufactories have already been noticed in our article Drogheda, and in the description of the other towns. In the parish of Clonmore there are 53 looms employed in weaving linen for the Drogheda market.

This county contains a great number of the high artificial mounds which prevail in Ireland, and are called raths. One of these raths, near the church of Rathdrummin, is in good preservation. It consists of an elevated area, 60 yards in diameter, encircled with a double fosse and mounds, the whole forming a circle 130 yards in diameter. A full account of them will be seen in Wright's *Louthiana*.

See Beaufort's *Memoir of a Map of Ireland*; Wakefield's *Statistical Account of Ireland*, passim; and Mason's *Statistical Account, or Parochial Survey of Ireland*, vol. i. p. 196, 203, and 622.

LOUVAINE, supposed to be derived from *Lo* and *ven*, which signify a hill terminating a plain, is a town in the kingdom of the Netherlands, and formerly the capital of Brabant. It is situated on the river Dyle, about four leagues from Brussels, and as much from Malines. In the year 1700, it was about five miles in circuit, including many fine gardens and meadows. It had eight gates, three market-places, and fifty-three towers within its walls, one of which, called *Verlorencost*, was so high, that in a clear day the towns of Antwerp and Brussels could be distinctly seen from it. It had 14 corn mills, 12 great streets, which traversed the city from one end to the other, 140 other streets, 16 stone bridges, and 14 public fountains. Its public buildings were then sumptuous, and its churches and monasteries were numerous and beautiful. Louvaine is now nearly decayed, and the principal objects of interest in it are the Maison de Ville, the cathedral, and the church of the Franciscans, which contains the tomb of Lipsius. The Maison de Ville is a curious specimen of the florid Gothic, and is larger and more elaborately wrought than Henry VIII.'s chapel. The cathedral is large and uniform. The two massive and lofty towers on the west front were the base of three spires blown down in 1604; the central one exceeded 560 feet in height.

The university of Louvaine was established in 1426, by John IV. duke of Brabant, and was enriched with high privileges by the Popes Martin V. and Eugene IV. which were confirmed and augmented by Philip II. king of Spain. It had more than 20 colleges, which were much admired for their situation and their architecture; but in this, as in almost every other respect, it has lost its importance. At the beginning of the 14th century, 4000 houses were inhabited by clothiers, who employed about 105,000 workmen; and it is a traditionary report, that when the weavers left off work, it was announced by a large bell, in order that the children might be taken home, lest they should be trampled to death by the crowd of workmen. In 1380, these workmen revolted against Stanislaus, duke of Brabant, and laid waste the country. Having been besieged, they were all taken and banished, and from that time the trade of Louvaine declined. Some trade is carried on here, in oil of turpentine, colzat, grain, hops, and spiceries. The grain and hops are of a very fine quality. Beer is made in great quantities, and sent to Antwerp, Brussels, Liege, Tirlemont, and other places. Vessels under 150 tons can come up to the town; but larger ships are obliged to unload at Antwerp. Population 18,000. East Long. 4° 41′ 46″. North Lat. 50° 58′ 26″.

LOW COUNTRIES. See Brabant and the Netherlands.

LOWESTOFF, a market town of England, in the county of Suffolk, is situated upon the most eastern point of the English coast, on a lofty eminence, commanding a fine view of the German ocean. It consists of one principal street, gradually descending from north to south, and intersected by several smaller streets and lanes, all of which are paved, but narrow, and built in an irregular manner. The houses on the east side of the high street, which stands on the summit of the cliff, face the sea. At the bottom of the eminence, the sides of which are converted into gardens, is a long range of buildings or fishing-houses, extending the whole length of the town.

The parochial church of Lowestoff is situated about half a mile west of the town. It is a fine building, in the pointed style of architecture, and 43 feet high, 57 broad, and 182 feet long. The tower, including a leaden spire of 50 feet, is 120 feet high. In consequence of the distance of the church, two chapels were erected here before the Reformation. One of these has been destroyed by the sea, and the other, which had gone to ruin, was rebuilt in 1698. There are meeting-houses also for the Presbyterians and Methodists. The other public buildings and establishments are the *corn cross*, the grammar school, founded by Mr. Annot, Wilde's school, for instructing forty boys in Latin and writing, a theatre, the batteries and forts erected for the defence of the town in 1774, 1782, &c. &c. and the lighthouses, erected on an elevated point of land over the edge of the cliff, (see our article LIGHTHOUSE, in this volume, p. 7.) The principal part of the trade of this town consists in the herring fishery. Previous to 1781, there were only 33 vessels annually employed in that fishery, which averaged about 21 lasts for each boat, (each last being equal to 10,000 herrings.) In 1802, about 30 boats gained 30,000*l.* the price of the fish cured; and in 1803, they earned in six weeks 10,000*l.* by mackarel. The mackarel fishery, in which 23 boats are engaged, commences in the end of May, and continues till the end of June, supplying the London market; and between June and October, when the herring fishery commences, plenty of fine soals are caught. The manufactures of Lowestoff are, fine and coarse pottery and cordage. It has lately been much resorted to for sea-bathing, and four bathing machines are kept for this purpose. The town and parish contained, in 1811, 623 houses, 673 families, and a population of 3189. See the *Beauties of England and Wales*, vol. xiv. Suffolk, p. 376; and Gillingwater's *Historical Account of the ancient town of Lowestoff*, 4to. 1790.

LOYOLA, INIGO DE (in Latin, IGNATIUS.) This extraordinary man, who instituted, and long governed the celebrated order of the Jesuits, was born in the reign of Ferdinand and Isabella, in the year 1491, in that part of Biscay called Guipuscoa. Don Bertram, his father, held a high rank among the nobility, and his mother was allied to the Counts of Puebla. Inigo was the youngest of seven children; and passed his first years with Don Juan Velasco, grand treasurer to his Catholic Majesty. Don Juan having no children of his own, requested that Inigo might reside with him; and he paid every attention to the education of his friend's son. When he had attained his 14th or 15th year, Inigo was sent to court, and was made one of the king's pages: but being of a disposition too restless to relish the unvaried life of a courtier, he resolved to become a soldier. Glory and love were his predominant passions; he was brave, and skilled in his profession, which he steadily followed till he was thirty years of age. He then suddenly became disgusted with the world, and resolved to lead the life of an itinerant saint, and to surpass all who had gone before him in a similar career. This change in his character is said to have been occasioned by a wound he received at the siege of Pampeluna in the year 1521. One of his legs was broken, and the rude surgery of those days brought on a violent fever, which probably affected his understanding. Under its influence, it is said, that he had a dream in which St. Peter appeared to him, and thanked him for the praises he had bestowed in a poem which Inigo had dedicated to him. This dream made such an impression, that he soon recovered. While in a state of convalescence, he asked permission to read, and a book, entitled "The Flower of the Saints," was put into his hands. This work, full of the most wonderful stories, could not fail to operate powerfully on a mind predisposed to relish its contents. Men wandering about the world without provision, and submitting to every sort of hardship; noblemen covered with coarse vestments, girded with heavy iron chains, and living in frightful deserts, or in horrible caverns, filled him with astonishment and admiration. He resolved to imitate these devout personages; to clothe himself with a sack; to feed on bread and water; to sleep on the ground; to use severe discipline; and to search for some dark cave for his residence. To crown all, he determined to undertake a pilgrimage to the Holy Land barefooted.

At this time his father was dead, and his eldest brother possessed the chateau of Loyola. In spite of all Inigo's caution, his brother saw, from various symptoms of a deranged intellect, that some wild scheme was in his contemplation. Don Martin besought him not to destroy the fair reputation he had gained at the siege of Pampeluna, nor to tarnish the honour of an illustrious house by a foolish and extravagant devotion. Inigo replied very coolly, and observed, "that he had no intention of doing any thing foolish, or that might in any degree obscure the glory of the house of Loyola." His brother was, by this speech, lulled into security; and while he indulged the hope that nothing disagreeable would happen, Inigo mounted a mule, and departed from Loyola.

Having arrived at Montserrat, he there devoted himself to the service of the Virgin, by becoming her knight, and made a vow of perpetual chastity. He now began to practise the most severe austerities. He flogged himself several times a-day, and disfigured himself so much, that he was pointed out and hooted at in the streets. Afterwards he retired to a cave, and continued to exercise discipline on himself. At length he became melancholy; and after brooding over his sins for some time, he persuaded himself that his eternal damnation was certain; and he became quite insane. He believed himself to be in hell, and uttered the most frightful cries. The monks of a neighbouring convent having compassion for his miserable condition, took him from his cave. But in spite of their care his frenzy continued to increase, and lasted a considerable time. At last it changed into a quiet reverie, during which he saw many visions. With difficulty he was prevailed on to take some food; but the fatigue occasioned by his visions brought on a dangerous illness. A new scheme having occurred to him, of consecrating himself to the evangelical ministry, he became less austere. He put on a better dress, kept himself comfortable, and having regained strength, he once more sallied forth.

He not only preached, but he wrote; and his first performance was his "Spiritual Exercises." He did not lose sight, however, in his new calling, of the Holy Land; and now freely communicated his schemes to his friends, who endeavoured in vain to dissuade him from executing his plan. He went to Barcelona, from whence he sailed to Italy. At Rome he kissed the feet of Pope

Adrian VI. and received a blessing on his intended pilgrimage to Jerusalem. From Rome he went to Venice, where he was hospitably entertained by a devout senator. But disliking a life of ease, he became impatient, and set sail for the Holy Land. On board of ship he was exceedingly irritated by the loose manners of the sailors, and so teazed them with exhortations, that they threatened to put him on shore in some desert place. The wind being fair, they put into the island of Cyprus, where Inigo found a vessel ready to sail with pilgrims. He immediately went on board, and arrived at Jaffa in August 1523. Having visited all the holy places, he set about attempting to convert the Mahometans. But the Head of the Franciscans established at Jerusalem, after reasoning with Inigo in vain, was obliged to use the authority delegated to him by the Pope, by ordering him to leave the country. Persuaded that God wished him to leave Palestine, Inigo disregarded the rudeness with which he had been treated. He set sail on his return to Italy in the month of November, and after a short stay in Cyprus, arrived about the end of January 1524.

Inigo now began to aspire to higher exploits; and feeling the want of knowledge, he resolved to commence a course of study, and for that purpose went to Barcelona. At the age of thirty-three, he began to learn the Latin language. He vowed to devote two years to study; and besought his master, if he did not learn as he ought, to flog him as he would one of his young pupils.

While he was engaged in his studies, he very nearly lost his life. Near the town of Barcelona there was a convent of Dominicans, called the monastery of St. Agnes. The females of this convent, far from being vestals, lived the devoted priestesses of Venus. Inigo resolved to attempt their reformation; and having insinuated himself into their confidence, he remonstrated against their debauchery, and exhorted them so powerfully, that they broke off all connection with their admirers. The gallants having discovered that their exclusion had been the work of Inigo, threatened him with the bastinado if ever he again approached the convent. He disregarded their threats, but they kept their word. In spite of this cruel treatment he persevered in his visits; and his enemies having determined to assassinate him, he was one day, as he was passing along in company with a priest, violently assaulted. The priest was killed, and Inigo left for dead. On his recovery, he returned to the nuns, and on their telling him his danger, he exclaimed, "How happy should I be to die, to save the soul of my neighbours!" No farther danger, however, awaited him; for, fearing the arm of justice, his enemies asked and obtained his forgiveness.

Having studied the Latin language during two years, he went to the monastery of Alcala, recently established by Cardinal Ximenes, in order to acquire some knowledge of theology and philosophy. Having formed, while at Barcelona, the design of instituting an order of Spiritual Knight-errantry, he had made some converts there; but fearing the inquisition of Toledo, he permitted only three of them to attend him to Alcala.

It would be tedious to follow Inigo through all the vicissitudes of fortune which encountered him. We have given the preceding outline of his early adventures, chiefly for the purpose of exhibiting the state and propensities of his mind. There may be some doubt of his ever having been actually deranged; for it is evident that sufficient sagacity remained, to enable him to conduct himself in such a manner as to make use of the superstition and fanaticism of the times in which he lived, to gain proselytes to his scheme of Spiritual Knight-errantry. Towards the accomplishment of his plans, it was obviously of importance that he should acquire notoriety; and that was certainly to be attained by a life of austerity, firmness in suffering, and a bold defiance of the world. Although it does not appear that he ever made any great progress in learning, it is evident that he possessed talents of the first order, but of a peculiar cast.

In Spain he met with so much ill treatment, that he resolved to leave it; and departed from his native country for France at the close of the year 1527. He reached Paris in the month of February; and, at the age of 37, recommenced his studies in the College de Montaign. It was not long before he was obliged to leave it, in consequence of his having been robbed by one of his companions, to whom he had entrusted the keeping of his cash, which forced him to go a begging into Flanders and England. Having recruited his finances in this manner, he returned to the College de Montaign, and afterwards entered that of St. Barbe, where a remarkable incident in his history occurred. Having, by his exhortations, brought a great many of the students into his particular way of thinking and devotion, he was condemned, on the complaint of one of the professors, to be flogged in the presence of the whole college. At the time when this sentence was passed upon him he happened to be out of the college, and he was earnestly advised by his friends not to return. Inigo was not to be deterred, and he entered boldly. The gates were instantly closed, and preparations made to inflict on him the ignominious punishment. He went directly to the chamber of the Principal, Govea, and pronounced a speech, which had so powerful an effect, that, without reply, he was led into the hall where the professors and students were assembled on the occasion of his disgrace; and while it was expected he was to be delivered over to the executioners, Govea fell at his feet, asked his pardon, and pronounced a warm eulogium on his firm devotion to the cause of religion.

As a curious instance of the extraordinary methods which Inigo adopted for the reformation of sinners, the following circumstance, which happened about this time, seems worthy of being recorded. He discovered that a person of his acquaintance had an affair of gallantry with a woman who lived in a village near Paris. One day, about the time when he knew this person was about to visit his mistress, Inigo placed himself up to the neck in a pond by the way side; and though it was mostly frozen over, he waited patiently till the sinner approached. "Whither goest thou, unhappy man?" he cried: "Hearest thou not the voice of the thunder? Seest thou not the sword of divine justice ready to strike thee?—Go! conquer thy sinful passion, and I will here suffer for thee till the wrath of heaven be appeased." The man was so forcibly struck with this singular action and address, that he immediately promised to amend his life, and returned.

After he had bound his disciples, by every means in his power, to serve him with fidelity, Inigo opened to them his scheme for the spiritual conquest of the world, which they received with a degree of enthusiasm that charmed him, and led him to resolve to procure the approbation of the Pope with as little delay as possible. He now returned to Spain; and, arriving at Loyola, his brother again attempted to dissuade him from continuing in a way of life which disgraced the family;

but he was altogether unsuccessful. Inigo went on, with the assistance of a select number of disciples, preaching and converting; and having at length made every necessary arrangement, and established in his mind the plan of his order, he set out for Venice, where he arrived about the end of the year 1535. Here he added to the number of his followers; and the disciples he had left at Paris and other places joined him. He sent a deputation to Rome, the result of which was, that he and his disciples received the order of Priesthood from Paul III.

The war between the Venetians and the Turks having interrupted the communication with the Levant, Inigo proposed to his companions to give up the project of visiting the Holy Land, and to offer their services to the Pope, to which they agreed. Accordingly, with Le Fevre and Laines, his favourite disciples, he repaired to Rome. It was resolved that the rest should disperse themselves among the most celebrated schools of Italy, for the purpose of adding to the troop. Before separating, they agreed to some general regulations, to which they bound themselves strictly to adhere, viz. that they should lodge in the hospitals, and beg their bread; that when a few happened to be together, they were to be superiors by turns; that they were to preach in the most public places, catechize children, and receive no reward for their good offices.

Inigo and his companions arrived at Rome about the end of the year 1537, and were well received. He now proposed that they should establish themselves as a troop of spiritual knights, with the title of the order of Jesus. Having arranged their plans, they waited impatiently for the return of the Pope, who had gone to Nice, to be present at the interview between Charles V. and Francis I. During this interval, it happened that a certain monk preached in Rome the doctrines of the primitive Christians. Inigo thought he had discovered that this preacher was in reality a Lutheran, and publicly opposed him. Unfortunately, however, the preacher was powerfully supported by three Spanish noblemen, who took great pains to publish the former misfortunes and disgraces of Inigo, who was nearly overwhelmed by the storm which they excited. His presence of mind, however, did not forsake him; and, by bold undaunted conduct, he defeated all his enemies.

On his presenting the plan of the new order to the Pope, his holiness, observing that its members were to be bound, in the strictest manner, to implicit and blind obedience to himself and his successors, exclaimed that the hand of God directed the scheme. Cardinal Guidiccioni for some time strenuously opposed the establishment, but at length consented to it. A bull was issued by Paul III. on the 27th September, 1540, which finally sanctioned the new order by the title of the Company of Jesus. At first the number was limited to 60, but this restriction was afterwards removed.

Inigo was elected general of the order, and assumed the government in the year 1541. He lived to see its power extended over Europe and the Indies, over China and Abbyssinia. He died at the age of 65, in July, 1566, sixteen years after the establishment of his order. At the earnest solicitation of the Emperor Ferdinand, Louis XIII. and Maximilian, Duke of Bavaria, Inigo was canonized by a bull of Pope Gregory XV. which was published by Urban VIII. after the death of Gregory, which happened soon after he consented to the canonization.

For the history of the order, after its establishment in 1540, the reader is referred to the article Jesuits.

The life of Inigo has been minutely written by a number of authors, and a great variety of frivolous stories have been recorded. In drawing up the above outline, we have consulted chiefly the work of Rasiel de Selva, who appears to have examined with great care all the preceding authorities. (s. k.)

LOZERE is one of the nine southern departments of France, which derives its name from that of a mountain in the department. It is composed of the ancient Gevaudan. It is bounded on the north by the departments of the Upper Loire and the Cantal; on the west, by the department of the Aveyron; on the south, by that of the Gard; and on the east, by that of the Ardeche. It is about 18 French leagues long, and 15 broad, and contains 5390 square kilometers, and 273 square leagues. The Lozere is a mountain of the Cevennes, and covers nearly one-third of the department from south to east. The northern districts consist partly of granite mountains. The hills are calcareous towards the middle of the department, and in the southern part, the Cevennes consist of schistus. In the south-east quarter of the department, the only productions are chesnuts, and apples, and mulberries, on which the silk-worm is reared to a considerable extent. In the interior, in the districts of Meude and Marvejols, the productions are wheat, grain, pasture, and fruits. The principal trade of the department consists in wool and cattle. At some distance from Meude are the mineral waters of Bagnols; and, in the same canton, there are mines of silver, tin, and copper.

The county near Langogne is remarkable for its beautiful pines, admirably fitted for masts, but there are no means of transporting them.

The principal towns are,

	Population
Meude	5014
Marvejols	3611
Florac	1905

which are the chief places of the three districts of the same name. Meude is the capital of the department.

The forests occupy about 44,000 acres, of which four-fifths belong to individuals; the contributions, in 1803, were 892,776, and the population 153,936.

LUBECK, a city of Germany, and one of the three cities of the Hanseatic league, is situated in Holstein, on the navigable river Trave, which has several communications with the German Ocean and the Baltic Sea. The town, which is said to rival Berne in beauty, is built on the two sides of a long hill of considerable height, the western part stretching towards the Trave, and the eastern part to the navigable river of Wackenitz. It is encircled with walls and towers, and also with strong ramparts and moats. The streets are in general steep, and the houses are built of stone, and in the old fashion, with doors so large as to admit carriages into the hall, which often serves as a coach-house; the walls of many of the houses bearing the date of the fifteenth century. The principal public buildings in Lubeck are, the cathedral, which contains a fine picture of the passion and death of Christ, painted by a pupil of the celebrated Albert Durer;—the church of St. Marie, in which the marble altar, the pulpit, and the clock, are deserving of notice;—the Hotel de Ville, containing paintings in the hall of audience, and the sculpture in the chamber of the treasury;—the Arsenal;—the Exchange;—the Convent of St. John;—the Poor's House and House of Correction, the stone stair of which is much admired;—the Hydraulic machinery, near the gate of Hoexter;—and the Gate of Holstein. The principal literary and useful establishments of Lubeck, are the College and the Patriotic Society. There is a public library, a cabinet of curiosities, belonging to M. Tesdorf, and a cabinet of paintings, belonging to M. Rodde. There are various manufactures carried on at Lubeck, the principal of which are tobacco, soap, hair powder, playing cards, woollen and silk goods, cordovan, bend-leather, pins, hats, &c. There are also refiners of sugar, bleachers of wax, cleavers of whalebone, and turners of amber. "The quay of Lubeck," says Mr. Coxe, "is on the river Trave, which falls into the sea at the distance of 14 miles, and admits vessels from 150 to 200 tons burden, and sometimes, but rarely, 300. I observed about 120 merchant ships, destined to Russia, Sweden, and Denmark. The trade is chiefly a trade of commission, drawing from Russia, Sweden, and Denmark, their raw commodities, and supplying them with wine, silks, cloth, and steel ware." In the year 1796, there arrived at Lubeck from Petersburgh, seventy ships, whose cargoes amounted to more than eight millions of francs; and, in the same year, it had four refineries of sugar, fourteen manufactories for tobacco, and seven for hats. In 1802, there arrived in all 1368 vessels, and cleared out 1234, as follows:

	Arrived.		*Cleared Out.*
Rostock	88	Rostock	101
Petersburgh	80	Petersburgh	72
Calmar	60	Riga	73
Carlshamm	68	Dantzig	83
Isle of Gothland	44	Amsterdam	35
Stockholm	42	Stralsund	35
Riga	40	Stockholm	17
Copenhagen	36	Bourdeaux	10
Dantzig	26	L'Orient	1
Amsterdam	16	Nantes	1
Bourdeaux	10	Lisbon	1
Marseilles	2	Riga	2
Nantz	3	Archangel	1
Newcastle	7		

At this time Lubeck had about 70 or 80 ships of its own: The trade of this place is now greatly diminished. The principal export is wheat, of the same quality as that from Mecklenburg. Salt is also exported. Travemunde, about nine miles distant, is the port of Lubeck. Population 42,000. East Long. 8° 40′ 52″; North Lat. 53° 51′ 18″. See Coxe's *Travels in Poland*, vol. v. p. 244; Catteau's *Tableau de la Mer Baltique*, p. 295; and Rordanz's *European Commerce*, p. 163.

LUCAN, (Marcus Annaeus Lucanus,) an eminent Roman poet, was born at Corduba, in Spain, about the year 39 of our era. His father, Annaeus Mela, was a Roman knight, and the youngest brother of Seneca the philosopher; his mother was daughter of Acilius Lucanus, an eminent orator.

Lucan was brought to Rome from the place of his nativity when eight months old; and his early education was committed to the care of the ablest masters in grammar and rhetoric. He studied philosophy under the stoic Cornutus, who has been so warmly celebrated by his disciple Persius, the satirist. With the view of completing his education, he is supposed to have passed some time at Athens. On his return to Rome, he was introduced into public life by his uncle Seneca, who was then tutor to the emperor Nero; and he obtained the office of questor before he was of the legal age to exercise it. He was afterwards enrolled among the augurs, and united himself by marriage with Polla Argentaria, the daughter of a Roman senator, and a lady of a most amiable character.

At an early age Lucan had exhibited proofs of poetical talents, and had acquired reputation by several compositions. Unfortunately, he ventured to compete with Nero, who was ambitious of being considered as the greatest poet and musician of his time. After a public recitation before a large assembly, at the festival of the *Quinquennalia*, the judges awarded the prize to Lucan. From that period Nero became the persecutor of his successful rival, and even forbade him to produce any poetry in public. Soon after, Lucan took a part in the well-known conspiracy of Piso against the tyrant. The plot was discovered, and he was apprehended among the other conspirators. Tacitus, the historian, affirms, that Lucan was induced to join in the plot by the injuries he had received as an author; and he has cast a deep stain on the memory of the poet, by expressly asserting, that Lucan, when accused of the conspiracy, for some time denied the charge; but, on being threatened with the rack, and tempted by a promise of pardon, he had the weakness to name his own mother, Atilla, as one of his accomplices. From this charge Mr. Hayley, in the notes to his *Second Epistle on Epic Poetry*, has attempted to vindicate him, and considers the imputation as a calumny invented by Nero. But it would require strong grounds to induce us to set aside the authority of so weighty an historian as Tacitus, who certainly was not inclined to calumniate the friends of freedom.

Having been condemed to death, Lucan met his fate with great firmness and intrepidity. He chose the same death with his uncle Seneca, and had his veins opened. When he found himself growing cold and faint through the loss of blood, he recollected some lines of his own, which described a wounded soldier expiring in a similar manner. These lines he rehearsed, and they were the last words he uttered. He died, A. D. 65, before he had completed his twenty-seventh year.

The only production of Lucan which has been transmitted to our times is his *Pharsalia*, an epic poem, which contains an account of the civil wars between Cæsar and Pompey. The critics differ very widely with regard to the merits of this poem. By some the author has been placed in the very first rank of epic poets; while others have disputed his title to be classed among poets at all, and have degraded him to the rank of a mere rhetorician and declaimer. The *Pharsalia* is an unfinished piece, with great faults certainly; but at the same time breathing a noble spirit of freedom, and exhibiting many passages of genuine and sublime poetry. In the disposition of his subject, says Mr. Hayley, in propriety and elegance of diction, he is undoubtedly far inferior to Virgil; but if we attend to the bold originality of his design, and to the vigour of his sentiments; if we consider the *Pharsalia* as the rapid and uncorrected sketch of a young poet, executed in an age when the spirit of his countrymen was broken, and their taste in literature corrupted, it may justly be esteemed as one of the most noble and most wonderful productions of the human mind.

The best editions of Lucan are the *Variorum*, Leyden, 1669, 8vo.; the edition of Oudendorp, with May's supplement, ibid. 1728, 4to.; Burman's edition, ibid. 1740, 4to.; Bentley's Strawberry-hill, 1760, 4to. There is no Delphin edition of this poet; but one of the first classics printed under the French republic was a splendid

Lucan in folio, by Didot. The *Pharsalia* has been translated into French verse by Brebeuf, and into English by Rowe. See Taciti *Annal.*; Vossii *Poet. Lat.*; Hayley's *Second Epistle on Epic Poetry*, notes; and *Gen. Biog. Dict.* (*z*)

LUCAYA Isles. See Bahama Isles.

LUCCA, the capital of a small Italian republic of the same name, on the coast of Tuscany, and one of the most ancient cities of Italy, is beautifully situated near the river Perchio, on a plain, terminated by eminences. The city, which is about three miles in circumference, is regularly fortified with eleven bastions. The tour of the town may be made upon the walls in three quarters of an hour. The rampart is beautifully planted with lofty trees, and will admit a carriage. The streets are irregular, but broad and well paved, and the houses are well built. The principal public building is a stately palace, within which is a large arsenal. The Gothic cathedral, which had a richly furnished chapel, possesses the famous wooden crucifix, called *Volto Santo*, to which much veneration is paid. The cathedral, erected in the 11th century, is cased with marble, and ornamented with rows of little arches. The environs of the town are covered with villages, country seats, summer-houses, and vineyards. The oil of the territory of Lucca, which is of the first quality, amounts in value to 180,000 rix-dollars annually. Its paper manufactories have been long celebrated, and great quantities of paper are exported to Spain, Portugal, and the West Indies. An account of the history of the state of Lucca will be found in Denina's *Tableau Historique de la Haute Italie*, p. 323, Paris, 1805; and Eustace's *Travels in Italy*, vol. ii. p. 271. Population of the town 25,000. East Long. 10° 34′; North Lat. 43° 54′.

LUCERNE, a town of Switzerland, and the capital of the canton of the same name, is situated at the foot of Mont Pilatus, at the extremity of the lake of Waldstettes or Lucerne, at the efflux of the Reuss, which divides the town into two parts. The town, which is tolerably well built, is surrounded with walls, erected between 1360 and 1385. The principal public buildings and establishments are, the Hotel de Ville, the arsenal, the cathedral church, the orphan's hospital, and the library of the Ex-Jesuits. The chambers of the Hotel de Ville are exquisitely carved, and contain a picture of Wursch, representing the giving of the law on Mount Sinai, and portraits of the ancient chiefs of the state. The arsenal contains the banner of the town, stained with the blood of the Avoyer of Gundoldingen, who carried it at the battle of Sempach, and various other curiosities. The cathedral church has an organ of a fine tone and remarkable size, the centre pipe being 40 feet long, nearly three feet in diameter, and weighing about 1100 weight. The library of the Ex-Jesuits, and that of the Capuchins, contain many valuable works. The library of Felix de Balthasar is very rich in MSS. and works relative to the history of Switzerland. There is also at Lucerne a cabinet of natural history, belonging to the abbey of St. Urban; a cabinet of paintings, belonging to M. Reinhard; a magazine of fossils, at the house of M. Nager; and a cabinet of minerals, at the house of Colonel Pfyffer. The three bridges of Lucerne are deserving of notice. The bridge of the Mills, over the Reuss, is ornamented with the Dance of Death, the work of the painter Moglinger. The bridge of Kappel, built at the outlet of the lake, is 1000 feet long, and contains 200 pictures, representing the great exploits of the Swiss.

The most interesting curiosity near Lucerne is the slide at Alpnach, erected by M. Rupp in 1812, for the purpose of bringing down to the lake of Lucerne the fine pine trees on the sides of Mount Pilatus. This slide is 44,200 English feet long, or above 8¼ English miles, and terminates close to the lake. It consists of a trough, about five feet broad and four feet deep, formed of trees, and having its bottom wetted with water, conducted into it at various parts of its length. The declivity at its commencement is above 22½°. The large pines, after having their branches and tops cut off, are placed in the slide, and, descending by their own gravity, they acquire such an impetus by descending the first part of the slide, that they perform their course of 8¼ miles in the short space of six minutes. Under favourable circumstances, that is in wet weather, the journey is often performed in three minutes. Only one tree is carried down at once; but, by means of signals placed along the slide, another tree is launched as soon as its predecessor has plunged into the lake. These trees are formed into rafts, and floated down the Reuss into the Rhine. The company, at whose expence this singular work was erected, expended 9000*l.* upon it. The wood upon Mount Pilatus cost 3000*l.* A full account of this curious slide was lately read at the Royal Society of Edinburgh, by Professor Playfair, and will probably appear in Volume IX. Part I. of their Transactions. East Long. 8° 6′. North Lat. 46° 56′.

LUCERNE, See Agriculture.

LUCIA, St. one of the Carribbee islands, in the West Indies. It is about 32 miles long, from north to south, and 12 broad. It is divided longitudinally, by a ridge of hills, covered with forests, which shelter numbers of venemous insects and serpents. There are two hills, remarkably round and high, which appear to have been volcanoes; and in one deep valley there are several ponds, where the water bursts up with great violence, and retains some of its heat even at the distance of 6000 toises from its source. The island is divided into Basse-terre, the low or leeward territory, and Cabes-terre, the high or windward territory. The former is well cultivated, and the most populous; but the climate is unwholesome, from the abundance of stagnant waters and morasses. The latter division is also unwholesome, but it becomes less so as the woods are cleared away. On the west coast there is an excellent harbour, called the *Little Careenage*, with three careening places, one for large ships, and the other for frigates. It is accessible only to one vessel at a time, and is defended by several batteries. It is capable of holding 30 ships of the line. The island contains nine parishes, viz. eight on the leeward, and one on the windward division. There is a high road made round the island, and another which crosses it from east to west. The following table shews the nature and amount of the imports into St. Lucia in 1804, 1805, and 1806:

Articles imported.	1804.		1805.		1806.	
	From Great Britain.	*From United States.*	*From Great Britain.*	*From United States.*	*From Great Britain.*	*From United States.*
Corn - - - - -	3452 bushels	7727 bu.	221 bu.	4350 bu.	851 bu.	2222 bu.
Bread, flour, and meal		9322 cwt		11,780 cwt		7518 cwt
Rice - - - - -		362 bar.		376 bar.		229 bar
Beef and pork - -	193 barrels	1583 do.	477 bar.	2031 do.	241 bar.	1521 do.
Pickled fish - - -		850 do.	329 do.	489 do.	126 do.	353 do.
Butter - - - - -	604 barrels	529 do.	1094 do.	611 do.	872 do.	745 do.
Cows and oxen - -		287 do.		354		215
Sheep and hogs -		65 do.		207		60
Oak and pine boards and timber - -		1,000,547 feet	50,200 feet	1,792,300 feet	11,200 feet	912,273 feet
Shingles - - - -		2,072,000 No.	29,000	3,401,200	8000	2,901,000
Staves - - - -		187,584 No.	5,500	327,394		198,500

In the year 1777 St. Lucia contained 53 sugar works, 5,040,962 coffee plants, 1,945,712 cocoa-nut trees. In 1810 the official value of the imports were 193,743*l.* and the exports 43,830*l.* In 1777 the population amounted to,

Whites	2,397
Free blacks and mulattoes	1,050
Slaves	10,752
Total	14,199

This island was discovered on St. Lucia's day, and the English first settled on it about 1635. It was ceded to the French by treaty in 1763. It was reduced by the English in 1779; restored in 1783, and retaken by the British in 1795; restored, and re-captured in 1803; and again restored to France in 1815.

LUCIAN, a celebrated Greek author, was born at Samosata, a city of Syria, in the reign of the Emperor Trajan. His parents were poor; and, in his youth, Lucian was placed with an uncle to learn the art of statuary. Having conceived a disgust for this employment, however, he withdrew from his master, devoted himself to literary studies, and embraced the profession of a pleader. He afterwards retired from the bar, and confined himself to the practice of eloquence as a sophist or rhetorician. Under the Emperor Marcus Antoninus, he was appointed procurator of the province of Egypt. He is said to have died of the gout, in the reign of Commodus, at a very advanced age; but the precise period of his death is uncertain. His enemies fabricated a story that he was torn in pieces by dogs.

The works of Lucian are numerous, and consist of a variety of pieces, narrative, historical, critical, and satirical, principally in the form of dialogues. The most popular of his writings are those of a humerous description; in which he excelled so much, that he is generally esteemed as one of the most witty of all the ancient authors. The chief subjects of his ridicule are false religion and philosophy. He does not even spare the Christian religion; with which, however, he appears to have been very imperfectly acquainted. His language is pure, and his style generally elegant; and although he sometimes offends against decency, yet his writings, upon the whole, have a tendency favourable to good morals. Many of our modern wits have been much indebted to Lucian. His ideas have been frequently followed out, and his style imitated, by Le Sage, Fenelon, Lyttleton, Swift, Fielding, Wieland, and others.

The best editions of the entire works of Lucian are those of Bourdelot, Paris, 1615, folio; of Graevius, Amsterdam, 1687, 2 vols. 8vo.; of Reitzius, ibid. 1743, four vols. 4to.; and the Bipontine edition, 1789—93, ten vols. 8vo. His select dialogues, and some other detached pieces, have been frequently reprinted. See Vossii *Hist. Græc.* Moreri, Brucker, and *Gen. Biog. Dict.* (*z*)

LUCKNOW, the capital city of the province of Oude, in Hindostan, is situated in North Latitude 26° 51′, and East Longitude 80° 55′. It is mentioned by Abul Fazel as a town of considerable note in the reign of Acber; but its prosperity is dated from the year 1774, when it was selected by the Nabob Asoph ul Dowlah as the seat of government, in place of Fyzabad, the former capital. The bankers and men of property necessarily accompanied the court, and Lucknow became, in a few years, one of the largest and richest cities of Hindostan. In 1800, its population was estimated to exceed 300,000, or, according to others, 500,000; but the number is supposed to have rather diminished than increased since that period.

The town is about seven miles in circumference, and stands on the left bank of the river Goomty. This river is distinguished for the purity of its waters, and the scenery of its banks; is navigable for boats of the common size at all seasons of the year, and falls into the Ganges between Benares and Gazypoor, about 43 miles south-west of Lucknow. The houses of Lucknow are built of brick or mud, and many of them merely of mats and bamboos. The streets in which the lower classes reside are so narrow, that two small carts cannot pass one another; and, in consequence of clearing away the mud, or the blowing away of the dust, are hollowed out in the middle to the depth of 10 or 12 feet. The street which leads to the palace is upwards of five miles in length, for more than one half of which extent the passenger wades through mire and filth. "I never witnessed," says Mr. Tennant, "so many varied forms of wretchedness, filth, and vice." The city, however, has been greatly improved of late years, both by the last nabob, Saadut-Ali-Khan, and by the present prince, Rufful-ul-Dowlah; and begins to bear the palm of neatness and elegance of architecture from most of the cities of India. "An air of comfort," says the author of *Sketches of India*, "pervades the greater part of the city; and I remarked, with considerable satisfaction, that the loathsome and disgusting scenes of misery and poverty, so conspicuous in every other large city I had visited in India, were here either wholly unknown, or studiously concealed. The inhabitants carry on no trade, and produce no peculiar manufacture. There are consequently few rich shops or mercantile warehouses, and little appearance of affluence beyond the limits of the prince's family. But the best artisans and mechanics of every kind are to be found in the place, and receive every encouragement from the nabobs, who both employ them frequently, and pay them handsomely.

There are many fine buildings in different parts of the city: and the palaces of the nabob, the principal mosques, and the Mahommedan burying-places, particularly display the greatest splendour. The roofs and spires are gilt, and the whole architecture loaded with ornament; but, with all this external brilliancy, there is often little internal convenience or accommodation. The Imambarrah, or place of royal burial, built by Asoph-ul-Dowlah, at the expense of one million sterling, is greatly distinguished among these edifices, for the imposing grandeur of its external appearance, and the richness of its internal decorations. It is illuminated by a profusion of wax tapers in magnificent chandeliers, especially at the festival of the Mohurrun, or mourning for Hossein and Ali, on which occasion its expenses have frequently amounted to a lac of rupees. The interior of the building was much neglected by the late nabob; but the reigning prince has spent immense sums in adding to it ornaments of gold and silver lamps, crystal lustres, burnished mirrors, and embroidered canopies. In the apartment where Asoph-ul-Dowlah is interred, the decorations are formed of the most costly materials, such as solid plates of gold, silver, and ivory, inlaid with diamonds, rubies, and emeralds. The grave is strewed with flowers, gilt paper, and rich bread of barley from Mecca. On one side is a censor filled with perfumes; on the other the sword and sash of the deceased; and at the head, his turban and a copy of the Koran. A company of singers are employed in chanting verses from the Koran day and night. The stables of the nabob form a large square court of buildings, supported upon brick pillars; one range of which, examined by Mr. Tennant, contained four hundred stalls, filled with excellent Persian horses. There is also a large menagerie belonging to the prince, in which, however, less attention has been paid to variety and utility, than to the oddities of nature's productions. There are many tigers exceedingly tame, but kept in a very dirty state; a number of sheep, particularly of the Cabul breed, with large protuberances on the rump; a very large breed of Guzerat bullocks; elephants, camels, bears, monkies, porcupines, &c. But the most curious quadrupeds are two of the Ramghur hill-dogs, called dhool's, resembling large foxes, very brisk and lively animals, which are said, in the natural state, to unite in bodies of 400 or 500, and to hunt and destroy the most ferocious tigers. There is a vast variety of birds, especially cassowaries, pheasants, the most beautiful parrots, and, above all, immense flocks of pigeons. The whole establishment is supposed to consume as much food as might relieve the wants of the whole city, or even of the kingdom of Oude.

In the neighbourhood of the city is Constantia, now called Nurred Bux, the residence of the late General Martine, which is said to have cost 150,000*l.* sterling. It is placed close to the river Goomty, and constructed entirely of stone, except the doors and window-frames. The ceilings of the apartments are formed of elliptic arches, and the floors made of stucco. The lowest story contains two caves or recesses within the banks of the river, and level with the surface of the water at its lowest decrease, in which the proprietor generally lived during the hot season. When the rainy season commenced, and the increase of the river compelled him to remove, he ascended to the next story, where the apartments were fitted up in the form of a grotto; and when the river had reached also the level of this retreat, he proceeded to the third story as a ground floor, which overlooked the river at its greatest height. In the fourth story a handsome saloon, raised on arcades, and projecting over the river, formed his habitation in the spring and winter months; so that, at all seasons of the year, he preserved in his house a moderate and equal temperature. On the attic story was a museum, well supplied with various curiosities; and, above the whole, an observatory, furnished with the best astronomical instruments. A noble garden, and extensive clump of mango trees, are annexed to the house; and in the artillery yard, at a little distance, was erected a steam engine, where the proprietor used to amuse himself in making experiments with air balloons. There is a bridge of brick and mortar masonry over the Goomty; but another of cast iron, manufactured in England, and carried over in India ships, is about to be erected; and the introduction of many other European arts and improvements is daily advancing under the auspices of the present nabob.

Lucknow is the only court in India, except that of the Nizam, in which any degree of magnificence now prevails, suitable to the state or grandeur of oriental descriptions. The nabob maintains a high degree of splendour, and exhibits a striking specimen of an eastern prince. He has upwards of a thousand elephants, many thousands of fine horses, and innumerable palaces of great beauty and magnificence. The poorer classes in his capital seem to enjoy a considerable degree of liberty, sometimes rising to licentiousness, especially among the Mussulmans, who are ever ready to testify their dislike of British influence and individuals.

The river Goomty is crowded with boats, busily employed; and nothing can exceed the splendour of the nabob's numerous pleasure barges, budgerows, and other vessels, some of which are cased on the outside with silver plates, embossed with various devices, and with gilding below the water mark, while the decks are furnished with satin canopies, embroidered with silver, and even the masts and sails are richly decorated with fringes and tassels. Both sides of the river present the most enchanting views, and the banks are cultivated to the water's edge. Lucknow is 650 miles distant from Calcutta, 280 from Delhi, 202 from Agra, 189 from Benares, 923 from Bombay, 795 from Hydrabad, and 1201 from Seringapatam.

The district of Lucknow, lying between the 26th and 27th degrees of north latitude, is generally flat and sandy, yielding wheat and barley as principal crops. The towns are mostly built of brick; but the greater part of them are fuller of ruins than of inhabited dwellings. The natives are of a more robust habit and martial disposition than the Bengalese, and furnish many of the best recruits for the British sepoy corps. See Tennant's *Indian Recreations*, vol. ii.; Valentia's *Travels*, vol. i.; Rennel's *Memoir of a Map of Hindostan;* Hodge's *Travels in India; Sketches of India*, 1816. (*q*)

LUCMANIER, Mons Lucumonius, or Lokmajn, in the Rhetian language, is the name of a mountain, situated among the Grison Alps, between the Valley of Medels and the Val-Blegno. In 1374, the Abbé of Dissentis erected on the top of the hill the Hospice of St. Maria, for the maintenance of which he bequeathed considerable funds. The keeper of the hospice is bound to plant large poles from the bridge of Vicira to the frontier, to keep the road open, to show hospitality to strangers, and to give them every assistance in his power. This hospice, situated between the brooks of Curlim and Rondadura, occupies the highest point of the passage from Dissentis to Bellinzone, and is surrounded with extensive pasturages, called, in the old maps, Locus Magnus. The distance from Dissentis to the top of the hill is five leagues.

The valley of Kadelina (*Ka d'ol Rhin*, the *head of the Rhine*,) begins about half a league to the west of St. Maria. Its length is one and a half league, to the lake of Duin, from which issues the middle branch of the Rhine. This lake is sometimes frozen during the whole summer. From the top of one of the peaks of the Lucmanier, called Scopi, there is a very extraordinary view of the Alps. The distance from the Hospice to the summit is four or five hours' journey. See Ebel's *Manuel d'un Voyageur en Suisse* for further details respecting this mountain.

LUÇON. See Phillippine Isles.

LUCRETIUS, (Titus Lucretius Carus,) a celebrated Latin poet, was born, according to the Eusebian Chronicle, about the year 96 B.C. Of the circumstances and events of his life little is known. He appears to have studied at Athens, where he imbibed the doctrines of Epicurus. He is said to have put an end to his days in a fit of delirium, occasioned by a philtre, or love-potion, administered to him by his wife, or mistress, in the 44th year of his age. But the time and manner of his death are involved in uncertainty.

The reputation of Lucretius is founded upon a poem in six books, on the Nature of Things, in which he unfolds and illustrates the principles of the Epicurean philosophy. His language and versification partake of the rudeness of an early period of literature; and in some of the argumentative passages he becomes tame and prosaic. But where the subject admits of elevated sentiment, or picturesque description, he exhibits a great deal of spirit and sublimity. In this singular poem, the author, true to the doctrines of the system he had imbibed, contradicts the dogmas of all established religion, and controverts the existence of a first creative power, of a providence, and of the immortality of the soul.

The best editions of the poem *De Rerum Natura* are those of Creech, Oxford, 1695, 8vo.; of Havercamp, Leyden, 1725, 2 vols. 4to.; and of Wakefield, London, 1796, 3 vols. 4to. It has been translated into Italian by Marchetti; and into English, first by Mr. Creech, and lately by Mr. Mason Good, in 2 vols. 4to., with many learned, philological, and explanatory notes. The Cardinal de Polignac has refuted the arguments of Lucretius, in an excellent Latin poem, entitled *Anti Lucretius*. See Vossii, *Poet. Lat.* Bayle; Brucker; *Gen. Biog. Dict.*; and Mr. Mason Good's translation of Lucretius, London, 1805, 2 vols. 4to.

LUDLOW, a market-town of England, in Shropshire, is situated upon an eminence, at the junction of the rivers Teme and Corve, over the first of which there is a good stone bridge, in a fertile and beautiful district, on the southern border of the county. It is about a mile long, and half a mile broad. The streets, which are wide and well paved, diverge from the highest, or central part of the town, the principal one leading from the bridge to the town-house, and the next to the Horse Course. The houses are in general neat, and well built, and superior to most of the inland towns of the same antiquity. The principal public buildings are the church, the market-house, and the town hall. The church, situated in the highest part of the town, is a stately and venerable building, in the shape of a cross, with a lofty tower in the centre, having a peal of eight bells. It is ceiled with fine oak, and embellished with carving, and has some good painted glass. Its extreme length from west to east, is 228 feet. The organ, presented by the Earl of Powis about 70 years ago, cost 1000*l.* The market-house, situated in the middle of Castle Street, is open below, for the purpose of a corn-market; and the apartments above, supported by arched walls, are used for corporation meetings, balls, and assemblies. The town, or guild-hall, is a commodious modern structure, in Mill Street. Near the church is an alms house for aged widows and widowers, founded in 1486, by Mr. Hosier, and rebuilt in 1758. To the west of the church there is a building called the college. The prison, called Goalford's tower, was erected in 1764, on the site of a tower of that name. There is also here a grammar school, founded by Edward IV.; and at the top of Broad Street there is a handsome stone cross, the rooms over which are used as a public school. The town was once encircled with a wall, parts of which, and a gateway at the bottom of Broad Street, still remain. Ludlow Castle, now a ruin, stands at the north west angle of the town, on a bold wooded rock, which overhangs the river. The battlements are of great height and thickness. It is said to have been founded by Roger de Montgomery, soon after the Conquest. The town is governed by a high bailiff, a bailiff, two justices, 12 aldermen, and 24 common councillors, recorder, coroner, and chief constable. It sends two members to Parliament, chosen by about 500 electors.

The following was the population of the borough in 1811:

Inhabited houses, - - - -	851
Families, - - - - - -	1103
Families employed in trade, - - -	246
Males, - - - - - - -	1810
Females, - - - - - -	2340
Total Population, - - -	4150

See Grose's *Antiquities*; Lipscomb's *Tour in South Wales*; and the *Beauties of England and Wales*, vol. xiii. Part II. p. 238.

LUDWIG. See Botany.

LUES VENEREA. See Medicine.

LUGANO, in German *Lauis*, is a town of Switzerland, and the principal place of the canton of Tesino. It is situated on the north bank of the lake of the same name. The town is pretty well built of a sort of *tufa*, and its situation is extremely striking. To the east rises the fertile Monte Bré, or Gottardo, covered with villages, country houses, and on the opposite side, at the foot of Mount Caprino, are seen the caves called the *Cantines di Caprino*, which are a number of clefts or openings in the rocks, from which a cold wind always issues. On the 29th June, Reaumur's thermometer descended to $2\frac{1}{3}$° in these caves, when it stood in the open air at 21°.

In August it was 4½°, and in the open air 18°. In September it stood at 7°, and in the open air at 16°.

The principal public buildings in Lugano are, the palace of the Marquis di Riva, containing some good pictures; the convent of the *Zoccolante agl'angeli;* the church of San Lorenzo, remarkable for the beautiful carvings round the doors and windows.

On account of the passage of merchandize over the St. Gothard, Lugano possesses a considerable trade. There is here a small manufacture of woollen stuff; mills for spinning silk; manufactures of snuff, and also manufactures of paper and gunpowder. There are forges in the neighborhood, where iron and copper are wrought.

The lake of Lugano is 10 leagues long, and one broad. It is 198 feet higher than the lake of Como, 234 feet above that of Maggiore, and 882 feet above the sea. From 20 to 30 quintals of fish are caught in the lake every week, and sent to Milan. Population of the town 8000. East Long. 8° 53′; and North Lat. 45° 59′ 56″. See Coxe's *Travels in Switzerland*, vol. iii. p. 308; and Ebel's *Manuel d'un Voyageur en Suisse.*

LUGNETZ, or Longnaza, is a valley in the canton of the Grisons, which opens near Ilantz. It is eleven leagues long, with many lateral vallies opening into it, which are almost unknown. Its wild rocky scenery, its magnificent waterfalls, frightful bridges, and fine glaciers, render it well worthy of being visited by travellers. Most of the inhabitants are Catholics. The Piz-Valrhein is the highest mountain, and is 10,220 feet above the sea. Most of the rocks are composed of argillaceous schistus. There are here mines of lead and copper, and great quantities of sulphate of magnesia, called the *sel des glaciers*, so that the apothecary of Ilantz is enabled to sell it at 20 florins the quintal. See Ebel's *Manuel d'un Voyageur en Suisse*, for a full account of the valley and its natural curiosities.

LULLY Raymond. See Alchemy, Chemistry.

LUMBAGO. See Medicine.

LUNACY. See Insanity.

LUNATIC Hospitals. See Insanity.

LUNDY Island, is an island of England belonging to Devonshire. It is situated in the British Channel, about five leagues north-west of Clavelly. It is more than three miles long, and one broad, and contains about 2000 acres. It is surrounded by high rocks, inaccessible excepting in one or two places. The highest points are 800 feet above the sea. About 400 acres are in cultivation, and it feeds nearly 400 sheep, and 80 head of cattle. The annual rent was 70*l.*; the number of houses seven; and the inhabitants 23. West Long. 4° 9′, North Lat. 51° 20′. See the *Beauties of England and Wales*, vol. iv. p. 249.

LUNULA, or Lune of Hippocrates, is the name given to an area, or crescent, bounded by a semicircle, and the convex side of the quadrant of another circle, whose radius is equal to the chord of 90 of the first circle. As the subject is too unimportant to be discussed at any length, the reader will be able to understand it by looking at Fig. 189, Plate CCLXXIV. where the crescent formed by the upper semicircle AD, and the quadrant AFD of the semicircle ADC, is the lunula of Hippocrates. Hippocrates demonstrated that its area is equal to that of a right angled triangle ABD. For since $BD^2 = 2\ BO^2$, the area of the quadrant BDA, is equal to the area of the semicircle standing upon AOB. From each of these take away the common part AODF, and the remainder, viz. the lunula above AFD, is equal to the remainder, viz. the right angled triangle ABD. See Geometry.

LUNENBURG, a town of Germany, in the kingdom of Hanover, is situated on the river Ilmenau, a small navigable river that runs north-west to the Elbe. It is of an oblong form, encircled with moats and walls, and fortified with towers, is two miles in circuit, and has three churches, and three hospitals. There is a great square, in which are the Palace of Princes and the Hotel de Ville. There is also a college here; an anatomical theatre, which was built in 1713; and an academy for martial exercises, which was founded on the site of the convent of St. Michael. The church of St. Michael, containing magnificent tombs, and a famous golden table, and the library of the town, and of M. Ebiling, are deserving of notice. The magistracy has consisted, since 1639, of patricians and men of letters, in equal proportions. In the part of the town called Salze, which is enclosed by walls, and has its own magistrates, there are 54 small houses sunk in the ground, and each containing four leaden pans, holding salt brine for the purpose of evaporation. Nearly 120,000 tons of salt may be manufactured annually; but only about 2000 lasts are exported. Each salt house, containing four pans, is estimated at 40,000 rix dollars, so that the capital of the whole Salze exceeds two millions of rix dollars. A fifth of the salt works belongs to the sovereign, and the town pays annually to the treasury 6000 rix dollars. Besides salt, the town exports beer, and lime from two rocks in its vicinity. It likewise trades in flax, honey, wool, linen, freize, and wax. This town carries on a considerable commerce of transit, and is one of the great entrepots of Germany. At the end of the town, upon an eminence, stands a fort, from which can be seen in clear weather, the tops of the towers of Hamburgh, at the distance of 36 miles. Population, 1300 houses, and 9000 inhabitants. East Long. 10° 36′, and North Lat. 53° 15′.

LUNENBURG, Duchy of. See Hanover.

LUNEVILLE. See France, and Meurthe.

LUNGS. See Anatomy, and the articles Medicine and Physiology.

LUPERCALIA, were feasts celebrated in Greece and Rome in honour of Pan, and derived their name from the Lupercal, the place where the sacrifices were performed.

LUPINS. See France.

LUSATIA. See Saxony.

LUSITANIA. See Portugal.

LUTHER, Martin, the celebrated German reformer, was born at Isleben, a town of Saxony, November 10, 1483. His father, John Luther, was a person of low birth, and a miner by occupation; but improved his fortune by his industry, and became afterwards a proprietor in the mines, and a magistrate of some rank in his native province. His mother, Margaret Lindeman, was descended of a respectable family, and had many relations among the most respected inhabitants of Eisenach. Luther was initiated, at an early age, in the knowledge of letters; and was, at the same time, anxiously impressed by his parents with a sense of religion. After acquiring at home the elements of grammatical learning, he was sent, at the age of thirteen years, to a school at Magdeburg, where he was obliged to support himself in a great measure by the charity of others; but, in the course of the following year, he was removed to Eisenach, where he enjoyed the countenance of his mother's friends, and studied with great diligence for the space of four years. At this period he gave abundant proofs of superior intellectual abilities, and especially of a natural genius for eloquence. In 1501 he went to Erfurt, where he passed through the usual course of logic and philosophy, and soon made himself master of all that was valuable in the scholastic system of those times. Becoming dissatisfied with these dry and thorny studies, he applied himself to the perusal of the best ancient authors; and in a short time acquired a high distinction among his fellow students, both for his knowledge of the language, and his familiarity with the sentiments of the Latin classics. At the age of 20 years, he took a master's degree in the University, and read lectures on Aristotle's works; but, in compliance with the wishes of his parents, he turned his attention to the study of the civil law, with the view of practising at the bar, or of raising himself in the state. His whole thoughts, however, were directed into a new course, by his narrow escape from a premature death, in consequence of a stroke of lightning, which threw him to the ground, and killed the companion of his walk. Without communicating his purpose to any of his friends, he withdrew himself to a monastery of the Augustines, where he resumed his scholastic studies, and submitted to the strictest monastic discipline. Here he became pre-eminent in all kinds of pious exercises and theological discussions; but, happening to get possession of a Latin Bible, he was astonished to discover how little of the Sacred Scriptures was generally known and understood. While thus devoting his mind, with the utmost avidity, to the study of the inspired writers, he was frequently agitated by the deepest emotions of religious alarm; and peculiarly anxious to ascertain the true will of God in every point of faith and practice.

An elderly priest in the monastery, to whom he had opened the distresses of his conscience, assisted essentially in rectifying his views on the remission of sin, and in directing his attention to the sentiments of the Apostle Paul on the fundamental doctrine of justification by faith. He derived additional information on these subjects from the works of Augustine, whose writings he preferred above those of all other divines. In 1507, after residing one year in the monastery, he made his profession, and took priest's orders; and in the following year was invited to the new university of Wittemberg, where he was employed for three years in lecturing on philosophy, in a manner which gave hopes of an entire revolution in the schools under his influence. In 1510, having been deputed to defend the cause of certain convents of his order in a contest with their vicar general, he repaired to Rome, where he found much to gratify his inquiring mind, and where he acquired no small insight into the weakness and corruption of the Papal Court. Upon his return to Wittemberg, he was appointed Professor of Divinity by the recommendation of Frederick, Elector of Saxony, who had often heard him preach, and was greatly struck with the superior matter and style of his discourses. In this office, he excited great attention by his expositions of the sacred book, and added no small weight to his sentiments by the rigid sanctity of his life. For the purpose of attaining a more complete acquaintance with the sacred Scriptures, he applied himself to the study of the Greek and Hebrew languages, and gave all the impulse of his exhortation and example to the cause of reviving literature. In 1516 he visited the monasteries of Misnia and Thuringia, in the capacity of subaltern vicar; and was soon after this excursion chosen to preach at Dresden, before George, Duke of Saxony, who was little disposed to relish his doctrines. In 1517, when Tetzel came to Wittemberg preaching the Papal indulgences, Luther was so much offended by the shameless tenets of this abandoned priest, that he published certain propositions on the nature of indulgences,* in which, without disputing the principle, he only condemned the errors of that individual preacher; but which were speedily assailed by numerous respondents, of whom the most distinguished were Prierias, a Dominican monk at Rome, and Eckius, professor of divinity at Ingoldstadt. He continued to maintain his sentiments in several elaborate answers, but still with great moderation, and with repeated declarations of his willingness to drop the question, provided the same silence were enjoined upon his adversaries. He addressed a letter to the Pope himself, expressed in the most dutiful terms, and indicating no views of separation from the Church of Rome; but evidently continued to experience considerable uneasiness, as, in the progress of his acquaintance with scripture truth, he found himself constrained to oppose the errors of popery. The violence of the Romish court, however, compelled him at once either to retract, or to revolt; and being summoned to Rome, to answer for his writings, he was summarily condemned as a heretic by Leo X. before the period of citation had expired; but having requested that his cause should be tried in Germany, and his petition having been seconded by Frederick, Elector of Saxony, Cardinal Cajetan, legate at Augsburg, was commissioned to take cognizance of the matter. At the first interview, Luther prostrated himself before the cardinal, by whom he was courteously received; but, instead of being admitted to any trial or inquiry, was uniformly urged to retract his errors, and avoid such discussions, in obedience to papal authority. He alleged the higher authority of scripture, and desired to be convinced by scriptural arguments. He was at length permitted to commit his answers to writing, for the purpose of being transmitted to Rome; but was dismissed by the cardinal with the most acrimonious expressions, and with strong injunctions to come no more into his presence, unless to make his recantation. Still did the faithful reformer discover an earnest desire of peace, and wrote a respectful letter to the haughty legate, requesting pardon for any irreverence of speech which might have escaped him in the heat of discussion, and renewing his professions of readiness to observe silence on the disputed points, if his opponents would do the same. Receiving no answer, he wrote in a more spirited tone, requesting permission to return home; and, after waiting four days for a reply, he became apprehensive of some designs against his safety, and secretly left the city of Augsburg. After his return to Wittemberg, he found himself proscribed by the Romish court; and, being doubtful of his patron's power to afford him protection, as well as unwilling to involve that prince in the same ruin with himself, he meditated a retreat to France, where the power of the Pontiff was less implicitly obeyed. But being requested by Frederick to remain at his post, he resumed his duties as theological professor in the university, and pastor of the town.

Nothing intimidated in the cause of truth, he protested against the bull which the Pope had issued in favour of indulgences, and appealed to the decision of a general council; but, after several conferences with Count Miltitz, the new legate in Germany, it was agreed that the cause should be referred to the first German diet of the new Emperor, Charles V. In the mean time, being still undecided on the point of obedience due to the Pope, he consented to write a submissive letter to his holiness; and, if only permitted to exercise freely his office as a public teacher, would gladly have remained a dutiful son of the church. As a proof also of his pacific disposition at this period, it may be mentioned, that he wrote an affectionate letter to the monk Tetzel, who had fallen into disgrace, and was lying on his death bed.

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* See in a note by Dr. Maclaine to Mosheim's *Ecclesiastical History*, Art. xvi. Sect. 1, and 2, a full reply to the false imputations brought against Luther in this part of his conduct, by Voltaire, Hume, and the popish writers.

In his answers to Eckius, (with whom he had been challenged to dispute publicly at Leipsic, in 1519,) he was led to canvass the grounds and extent of the Pope's authority; and, in his farther researches into the subject, began to question more decidedly the foundations of that power, as well as to attain clearer views of the rights of private judgment and liberty of conscience. Even at this stage of his own principles, he was disposed to regard the permission of providence, and the consent of the nations, as sufficient reasons for yielding to papal supremacy, while he denied its divine right; and, instead of that intemperance and temerity with which his conduct has been charged, he may seem to many, in these more enlightened and unfettered times, to have been more than duly cautious and submissive. He considered it as his proper business to conduct the studies of youth in theology, and to exercise the faithful preaching of the gospel; and used often to lament, that he had lived in an age which required him either to devote so many valuable hours to useless controversy, or to desert the incumbent duty of supporting his convictions of truth. In the beginning of the year 1520, according to the agreement with Miltitz, he addressed a letter to the Emperor Charles V. along with a protestation of his faith, imploring his imperial protection; and at the same time wrote to several German bishops, entreating a free trial of his sentiments. In the course of the same year he again addressed the Pope, to whom he gave a narration of his whole sentiments, and sent a treatise which he had composed on Christian liberty. He was forthwith condemned by his holiness as an inveterate heretic; and renounced, on his part, all farther views of reconciliation with the church of Rome. He was encouraged in his resolution by the offer of protection from several noblemen in Franconia; and, proceeding with new vigour in his opposition to a hierarchy, under which he was now persuaded that divine truth could not be faithfully taught, he published letters in the German language, exposing the Popish system, and inculcating the necessity of a reformation. Upon the publication of a damnatory edict against him, condemning him to punishment if he should fail to recant within the space of 60 days, he appealed, as formerly, to a general council, and issued tracts against the bull in his own defence, but certainly in a style of unjustifiable asperity. Knowing, however, that his appeal was disregarded, and expecting the thunder of actual excommunication, he adopted the daring resolution of separating himself from the Romish church, and publicly committed to the flames the pontifical laws, with the bull of his own condemnation. He next selected thirty articles from the code of papal statutes; and, writing a few concise remarks on each, printed the whole for circulation among the people. While he thus maintained his Christian liberty with the most undaunted courage, he was equally successful by his writings (particularly by his exposition of the Epistle to the Gallatians,) in promoting the doctrines of the Protestant faith. The revolution in men's religious sentiments by these means, proceeded with such rapidity, as to attract at length the attention of the imperial court, and, at the diet of Worms, in 1521, every exertion was made by his adversaries to carry into execution the sentence which had been issued against him. His friends having urged that he ought not to be condemned unheard, Luther was summoned to appear in person, and was furnished with a promise of safe conduct by the Emperor and Princes of the diet, accompanied with a letter from the Emperor himself, addressed to the reformer by the most respectful and honourable titles. Notwithstanding all these assurances, his friends were apprehensive of his safety; and, even when he was on the way, many attempts were made to dissuade him from proceeding. He was met at Oppenheim, particularly by Martin Bucer with a party of horsemen, who entreated him to take refuge in the castle of a friendly knight; and letters from others at the seat of the diet, presented the most discouraging prospects of his interest in that assembly. To all these remonstrances and representations he made the well known reply, "that, though he should be obliged to encounter at Worms as many devils as there were tiles on the houses, he would keep his purpose of appearing among them; and that all these fears of his friends could only be the suggestions of Satan, who dreaded the approaching ruin of his kingdom, from the confession of the truth before such an assembly."* As he stepped from his vehicle on his arrival, he said aloud, amidst a great concourse of people, "God will be on my side;" but his conduct before the diet was more temperate and decorous, than might have been anticipated from the spirit of fervency and fearlessness by which he was animated. Immense crowds followed him every where; and his apartments were daily filled by visitants of the highest rank. On his appearance at the diet, he acknowledged the books which he had written, and professed his readiness to yield to scripture argument; but resisted all solicitations and threatenings on the measure of recantation; and concluded his defence in these words: "Here I stand. I cannot do otherwise. May God help me: Amen." He was ordered by the Emperor to leave Worms, and not to preach on his way home; but, soon after his departure, he was suddenly carried off by a party of horsemen to the castle of Wartburg. For some time it was suspected that he had fallen a sacrifice to the machinations of his enemies; but it was afterwards known to have been a plan of his friend, the Elector of Saxony, with the concurrence (as has been conjectured) of the Emperor himself, to secure him from the designs which were apprehended against his life; and, indeed, sufficient indications of the most persecuting hostility were soon exhibited against him. After his friends had retired from Worms, on the supposition that his cause was dropped by the diet for the present, the Spanish and Italian nobles who remained, issued an edict, denouncing him as a heretic, prohibiting all persons from affording him protection, or printing, selling, and reading his works; and farther, enjoining all magistrates throughout the empire to commit his writings to the flames, wherever they could be found. This proclamation received very little notice in Germany, and the absence and occupations of the Emperor retarded, in a great measure, its execution. The reformer, in the mean time, remained safe at Wartburg, which he called his Patmos, corresponding with his friends at Wittemberg, composing tracts in defence of his tenets, and carrying on his German translation of the New Testament. When he went abroad for recreation, he was always disguised in the habit of a country gentleman, and sometimes joined in the hunting parties, though, as he said, with little love of the sport. After having been secluded in this manner about ten months, he appeared publicly at Wittemberg, without leave from the Elector, to whom he immediately wrote an apology for the step which he had taken; and particularly deprecated any attempt, on the part of that prince, to protect him by force. He applied himself with great success to allay the ferments which the ignorance of his followers had excited at Wittemberg; but continued, with unabated ardour, to make head against his most powerful assailants, Henry VIII. the pontiff, and the bishops. In 1522, he published a translation of the New Testament in the German language; and, about eight years after, that of the Old Testament was completed, with the assistance of his friends, Justus Jonas, and Philip Melancthon.

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* The reformer, when alluding to this declaration a short time before his death, is said to have made the following remark:—"So fearless can God render a man: I do not know whether, at this day, I should be so bold."

In 1523, notwithstanding another edict from the imperial diet at Nuremberg, he published treatises on the office of the supreme magistrate, on the worship of Christ's body in the eucharist, on the institution of the ministerial office in the church, on popish divinity, and on vows of virginity. He canonised two of his followers, Henry Voes and John Esch, the first martyrs for Protestantism, who were burnt at Brussels, and wrote consolatory letters to three ladies who were banished from Friburg for reading his books. In 1524, he wrote his treatise *De Servo Arbitrio*, as a reply to a work of Erasmus, whom he treated with considerable severity, on account of his indifference to the cause of those scriptural principles which he himself had commended. In the autumn of the same year, when none of the fraternity belonging to his monastery, except himself and the prior, remained, he threw off the monastic habit entirely, and soon after married a young woman named Catharine de Bore, who had been a nun. He assigned as reasons for this step, his desire to comply with the wishes of his father, to stop the mouths of slanderers, and to testify his unequivocal dissent from the popish injunction of celibacy. Many of his friends, however, disapproved of the measure, not as wrong in itself, but as unsuitable to the peculiar circumstances of the times. Though himself also ashamed of his precipitation, he was happy in his domestic state, and not a little delighted by the birth of his son. In addition to his contests with the Papists, he was seriously occupied in repressing the errors of the anabaptists, and the extravagances of other fanatical sects; and applied himself also, with the assistance of his friends, Melancthon and Pomeranus, to regulate the public service of religious worship, to appoint well qualified pastors over the Lutheran congregations, and to secure the revenues of the monasteries for the support of the parochial clergy, and the instructors of youth in schools. Nor did he diminish, amidst those important exertions, his ordinary labours in preaching to his congregation, writing letters to other pastors, and preparing useful works in his native tongue, for the religious instruction of the common people.

In the year 1527, when the students at Wittemberg, in consequence of a raging epidemic, were ordered to retire to Jena, he refused to desert his flock; and, in the course of the same year, he sunk into a state of severe mental distress, accompanied with a peculiar bodily disorder, which seems to have greatly humbled his mind, and particularly to have drawn from him the strongest acknowledgments of his intemperate spirit. He was heard to say, after one of these afflicting attacks, "I must mark the day; I was yesterday at school." About this time, a Jewish physician from Poland was detected in an attempt to take away the life of Luther by poison, and was saved from being tried by torture only by the request of the reformer himself. He was uniformly adverse also to every form of persecution, condemning all use of force in reducing religious errors, and admitting the application of punishment merely in cases attended by actual tumult and sedition; but, at the same time, he manifested a strange degree of dogmatism and virulence in the maintenance of his own opinions, even against the other Protestant leaders, particularly in the disputes with Zuinglius on the doctrine of the sacrament; and though, at the instance of the Landgrave of Hesse, he attended a conference at Marpurg on these topics, in 1529, he discovered no spirit of conciliation; and, while he admitted the duty of exercising mutual charity and civility, refused to acknowledge his opponents as Christian brethren.

In 1530, he furnished the materials of the Protestant Confession of Faith, to be presented by the leaders of the Reformation at the diet of Augsburg, as had been agreed upon at Smalcald; but this celebrated production was expressed and considerably modified by the elegant and temperate pen of Melancthon. Luther, at the same time, was busily engaged in preparing his lesser and larger catechisms, which are still regarded as of high authority in the Lutheran churches. After the meeting of this diet, and amidst the threatening appearances by which it was followed, Luther preserved the most undaunted spirit, always regarding the conflict as the concern of God, and considering himself as a mere instrument in the cause. His weight and influence were conspicuous in every measure connected with the interests of the Reformation; and his pen was not less powerful in animating his friends by private correspondence, than in defending his principles by publications from the press. He continued to display, on every occasion, a striking union of invincible and persevering fortitude, disinterested and decided zeal, and fervent, yet rational, piety. His sedentary occupations, and mental excitement, had begun seriously to affect his health, which had hitherto been supported in a great measure by his steady temperance.

In the beginning of 1537, while attending a meeting at Smalcald, he was afflicted by so severe an attack of the stone, that both himself and his friends despaired of his life. But he recovered his strength so entirely, as to be able to resume his usual labours in the press, the pulpit, and the divinity chair.

In 1545, his bodily infirmities and sufferings became more frequent and severe; and his enemies began to circulate the most laboured reports of his death and funeral; but the Reformer lived long enough to publish a contradiction of their malicious falsehoods. He became much chagrined about this period by the evident inclination of the Protestant world to favour the opinions of Zuinglius on the sacrament, and particularly by finding that his intimate friend Melancthon did not enter with sufficient ardour into his views of the subject. This, and some other altercations, made him adopt the resolution of leaving Wittemberg; but the earnest entreaties on the part of his friends, the students, and the inhabitants, which the rumour of this intention called forth, induced him to resume his former residence. In consequence of a dispute, however, between the courts of Mansfeld respecting the mines at Eisleben, the place of his nativity, he was prevailed upon, by the joint request of all parties, to undertake a journey thither for the purpose of composing the differences. He was accompanied by his three sons and his friend Justus Jonas, and was received in the most respectful manner by the noblemen concerned in the business, attended by a hundred horsemen, and a crowd of adherents to the reformed doctrines. After passing nearly three weeks at Eisleben his debility increased, and he died, in the 63d year of his age, on the 18th of February, 1546. The progress of his symptoms, and the circumstances of his last illness, may be read with more interest in the words of his friend Jonas. "Yesterday, Wednesday the 17th of February, Prince Anhalt, Count Schwarzburg, and the rest of us, prevailed on him to remain in his study till mid-day, and to do no business. He walked through the room in his undress, looked at times out of the window, and prayed earnestly. He was all along pleasant and cheerful, but took occasion to say to Coelius, (a clergyman of Eisleben,) and me, 'I was born and baptised at Eisleben; what if I should remain and die here?' In the early part of the evening, he began to complain of an oppression at his heart, and had it rubbed with a linen cloth. This afforded him some ease. A little after he said, 'It is not pleasant to me to be alone,' and repaired to supper in the parlour. He ate with appetite; was cheerful, and even jocular. He expounded several remarkable passages in Scripture; and said once or twice, in the course of the conversation, 'If I succeed in effecting concord between the proprietors of my native country, I shall return home and rest in my grave.' After supper, he again complained of the oppression at his breast, and asked for a warm linen cloth. He would not allow us to send for medical assistance, and slept on a couch during two hours and a half. Coelius, Drachsted, the master of the house, (whom he called in along with his wife,) the town-clerk, the two sons, and myself, sat by him watching till half past eleven. He then desired that his bed might be warmed, which was done with great care. I, his two sons, his servant Ambrose, whom he had brought from Wittemberg, and other servants, lay down in the same room. Coelius was in the adjoining room. At one in the morning he awoke Ambrose and me, and desired that one of the adjoining rooms might be warmed, which was done. He then said to me, 'O, Jonas, how ill I am! I feel an oppressive weight at my breast, and shall certaily die at Eisleben.' I answered, 'God, our heavenly Father, will assist you by Christ whom you have preached.' Meantime Ambrose made haste, and led him, after he got up, into the adjoining room. He got thither without any other assistance; and, in passing the threshold, said aloud, 'Into thy hands I commit my spirit.' He then began to walk about, but in a short time asked for warm linen cloths. Meantime we had sent into the town for two physicians, who came immediately. Count Albert likewise being called, he came along with the Countess, the latter bringing some cordials and other medicines. Luther, now praying, said, 'O my heavenly Father, eternal and merciful God, thou hast revealed to me thy Son, our Lord Jesus Christ. I have preached him, I have confessed him, I love him, and I worship him as my dearest Saviour and Redeemer—him whom the wicked persecute, accuse, and blaspheme.' He then repeated three times the words of the Psalm, 'Into thy hands I commit my spirit: God of truth, thou hast redeemed me.' Whilst the physicians and we applied medicines, he began to lose his voice, and to become faint; nor did he answer us, though we called aloud to him, and moved him. On the Countess again giving him a little cordial, and the physician requesting that he would attempt to give an answer, he said, in a feeble tone of voice, to Coelius and me, 'Yes,' or 'No,' according as the question seemed to require. When we said to him, 'Dearest father, do you verily confess Jesus Christ, the Son of God, our Saviour and Redeemer?' he replied, 'Yes,' so as to be distinctly heard. Afterwards his forehead and face began to get cold; and although we moved him, and called him by name, he gave no answer; but, with his hands clasped, continued to breathe slowly, until he expired between two and three o'clock."

The Counts of Mansfield were very desirous that his body should be interred in their territories; but, at the request of the Elector of Saxony, it was brought back to Wittemberg, and buried with great pomp in the church of All Saints. A plain stone was placed over the grave, with an inscription, merely expressing the name and the age of the deceased; but a portrait and an epitaph were afterwards affixed to the wall by order of the university. .

Luther was tall in his person, or rather inclined to a corpulent habit of body: yet he was remarkably temperate, and even sparing in his mode of living. "I have seen him," says Melancthon, "when he was in perfect health, absolutely neither eat nor drink during four days together. At other times, I have seen him, for many days, be content with the slight allowance of a very little bread and a herring on each day." But, while thus studious, sober, and a master of self-denial in private, he was of a lively, social, and open disposition, ready to partake freely at the tables of his wealthier friends, and able, even in his most afflicting periods, to exert himself for the entertainment of a company. He was frank and communicative even at a first interview; and his rich stores of knowledge rendered his conversation peculiarly interesting. The diffusion of religious truth being always the uppermost object in his thoughts, he was fond, when among his friends, of turning the conversation in that direction; but he was, at the same time, distinguished by the vivacity, humour, and even playfulness, with which he could treat of lighter topics. He was an enthusiastic lover of music, which was one of his most effectual restoratives in his seasons of dejection; and, before parting from his family and friends in the evening, he used regularly to sing a hymn in a delightful strain of voice*. His domestic circle presented a pleasing union of religious services, and of the kindest displays of conjugal and paternal affections.

By his unparalleled industry, and diligent employment of time, he had acquired a vast fund of religious knowledge; and even his enemies have been obliged to admit, that his genius and capacity were of the highest order. Though capable of long and patient study, he was able to bring forth his stores, and commit his sentiments to writing, with the greatest readiness, and published most of his books on the spur of the occasion, with very little care of correction. His compositions, consisting chiefly of controversial tracts, commentaries on Scripture, sermons, epistolary disquisitions, and narratives of the chief events of his life, are calculated by Seckendorff at the extraordinary number of eleven hundred and thirty-seven; and if to these be added the labours of his public duty, and the variety of his private correspondence, some idea may be formed of his indefatigable application. In such a mass of writing, it was not to be expected that much attention could be paid to the beauties of composition; and, besides, that the reformer's taste had been corrupted by the barbarous diction of the scholastic divines, he was himself utterly regardless of literary fame. In his reply to Erasmus, he showed himself capable of writing with considerable classical purity of style; but, in all his other productions in the Latin language, his sentences are long, his arrangement defective, his vocables often barbarous and made for the occasion, and many passages incapable of being understood. Many of his commentaries and sermons in his native language were printed from notes taken by his hearers; and, though generally shown to him beforehand, were allowed to go forth without much revision. But his German works are generally well written, and his translation of the Bible, as well as his hymns, have always been admired.

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* Besides being a lover of music, he was himself an admirable musician and composer; and the great Handel acknowledged, that he had derived singular advantage from studying the compositions of the Saxon reformer.

He professed to rest his theological sentiments altogether on the authority of Scripture; but they were evidently formed by degrees, and his views underwent various changes in the progress of his inquiries. This experience of errors, however, never moderated the ardour of his controversial writings, in which he invariably discovers the greatest confidence in the strength of his arguments, and the utmost contempt for the reasonings of his opponents; and while he is said to have entertained a peculiar predilection for the writings of Augustine, he imbibed no portion of that spirit of meekness by which they are characterised. This irritable and intemperate spirit was his great and prevailing fault, which led him often to think rather of inflicting the chastisement which his adversaries merited, than of supporting the character which became him as a Christian reformer. Hence he employed, with little discrimination, whatever weapons were calculated to reach his opponents; and poured forth, without reserve, the most overwhelming torrents of raillery, ridicule, sarcasm, and personal abuse. It ought indeed to be recollected, that many of his enemies had attained a height of wickedness in theory, and a shameless effrontery in practice, which could scarcely be denounced in terms sufficiently strong; and that his freedom of language, in addressing his superiors, proceeded in a great measure from his habitual impression of the paramount importance of those divine truths, which he considered himself as called to defend, as in the presence of God, against all earthly power whatever. His most passionate fits also appear to have been often the ebullition of the moment, and to have carried him, in the heat of composition, to greater lengths than he seems to have at first intended. They never appear to have proceeded from any malignant intention, or to have settled into a feeling of lasting animosity; and no man ever gave greater proofs of a humane, humble, generous, and placable spirit. It is certain, at least, that his asperity, however excessive, always evaporated in words, and that he was uniformly adverse to every kind of violent measures, whether of persecution against the weak, or of seditious resistance to the more powerful of his opponents. It ought finally to be added, that, while his natural benevolence of temper probably qualified him the better for the service to which he was called, and for the times in which he lived, yet he often suffered greatly in his spiritual comfort in consequence of such excesses, and sometimes bitterly lamented his want of self-government. He said, openly, before the Emperor at Worms, "I freely confess that I have been betrayed into an asperity of expression, which neither became me as a clergyman, nor as a Christian." And Melancthon relates, that he had heard him "confess, with deep sighs, and a vast effusion of tears, how intemperate he had been at times in his language; but appeal, at the same time, to Him, who knoweth all things, that his conscience did not reproach him with having harboured any ill-will."

The distinguishing feature of his character, as a religious reformer, was an undaunted spirit in the support of whatever he believed to be the truth of God; nor did this resolute courage proceed from any hasty impulse of feeling, but from a deliberate determination of mind, founded upon the most thorough conviction of duty. Equally regardless of the threats of enemies and the expostulations of friends, he persevered in the purpose which he had formed, and looked forward, with patience and confidence, to the final success of what he considered as a righteous cause. Nor were his uprightness and disinterestedness less remarkable than his courage. Though he became unquestionably one of the most conspicuous personages in Europe, visited by princes, and often consulted by senates, yet in no single instance did he attempt to convert his influence to his personal advantage. He was equally indifferent to the acquisition of wealth, honour, or literary fame; and no inducement could draw him from his favourite university and his pastoral charge. He lived and died in circumstances bordering upon poverty, and bequeathed to his wife and children little more than the respect due to his name. This alone proved to them an inheritance: and they were in a great measure supported by the liberality of his friends, particularly the Elector of Saxony, and the counts of Mansfield.

Luther appeared to great advantage in the office of a preacher. His sentiments, though generally distinguished at that period by their boldness and novelty, were plain and practical, free from all the subtleties of mysticism, or the idle austerities of monasticism. His mind was full of his subject; and his sole aim always appeared to be to bring it as fully before the minds of his hearers. Hence there was nothing laboured in his language, and nothing affected in his manner. His diction was copious, his elocution clear, his delivery ardent, and his own sincerity apparent in every sentence that he uttered. This, indeed, was the great secret of the effect which he produced. He never forgot his own concern in the momentous truths which he taught. He devoted himself to the illustration of sacred truth, not through motives of curiosity, or for the attainment of fame, but from a deep sense of their paramount importance to himself, as well as to every human being. See Bower's *Life of Luther*; Milner's *Church History*, vols. iv. and v.; Viller's *Essay on the Reformation, translated by Mill;* Mosheim's *Ecclesiastical History;* Melchior Adam *In Vita Lutheri;* Seckendorff *Historia Lutheranismi.* (q)

LUTON, a town of England, in Bedfordshire, is pleasantly situated among some hills upon the river Lea. It is a long irregular town, like the letter Y, with the streets diverging from the market-place. The houses are poorly built; and the only building deserving of notice is the church, which has a handsome embattled tower, and a hexagonal front of stone, which is much admired. The parish of Luton contained, in 1811, 725 houses, 783 families, and 3716 inhabitants. See the *Beauties of England and Wales*, vol. i. p. 30.

LUTTERWORTH, a town of England, in Leicestershire, is situated on the river Swift, and consists of three principal streets. The houses are generally built of brick, covered with tiles. The parish church is a large handsome building, containing a fine old carved oak pulpit, from which John Wickliffe diffused his opinions. The communion table is covered with the very garment he wore at the time of his death. Besides the church, there is a dissenting meeting-house, built in 1777. The cotton manufacture is carried on here to a considerable extent; and several large buildings have been erected for the purpose. Many hands are employed also in the stocking trade. The parish of Lutterworth contained, in 1811, 410 houses, and 1845 inhabitants. See the *Beauties of England and Wales*, vol. ix. p. 466.

LUTZEN. See Sweden.

LUXATION. See Surgery.

LUXEMBURG, the *Augusta Romandurum* of Ptolemy, is a town in the kingdom of the Netherlands. It is divided by the river Else into the upper and lower towns, the former being situated on a rock, and the lower on a plain. Its principal church is dedicated to St. Michael. Its fortifications were considered to be the strongest in Europe. Population 9000.

LYCURGUS. See Lacedæmon.

LYME, Regis, a borough and sea-port town of England, in the county of Dorset. It is situated on the river Lyme, near the sea on the west, lying between two rocky hills. The houses are built of blue ragstone, and covered with slate. The church is a neat building; and the custom-house is a modern building of brick, supported on pillars, and having the market-place beneath. The quay is commodious, and the harbour is defended by several small forts mounted with cannon. The cobb, or pier, is the principal public work here, and is now built with stone and cement, affording a shelter for shipping between that port and Portland Road. The harbour is considered one of the best in England, and the town is, on this account, likely to improve rapidly. The merchants have some trade in the Newfoundland fishery, and with the Mediterranean. Pilchards are cured here when they come so far up the Channel. The population of the borough in 1811, was 342 houses, 403 families, of which 202 were employed in trade and manufactures, and 1925 inhabitants. See the *Beauties of England and Wales*, vol. iv. p. 527.

LYMINGTON, a market town of England, in Hampshire, is situated on the declivity of a gently rising ground, on the west bank of Lymington Creek, or river, about a mile from the sea. It consists of one street, which is long and broad, and is divided into the old and new High-street by the church. In the former part the houses are old and irregular; but there are very excellant houses and inns in the other part. The principal manufacture of the place consists in sea salt. The average quantity made in the seven years, from 1796 to 1804, was 5000 tons, of which 2000 were annually exported to America. In 1804 there were but two works standing, of which only one half were in use, giving employment to about 80 men and boys. The common salt is made in summer, and in winter Epsom and Glauber salts are made from the residuum left in the drying troughs. This manufacture, owing to the increased price of coals, has greatly decreased. Before the year 1730, vessels above 500 tons could be brought up to the quay; but, from the improper construction of a causeway, the channel of the river has been contracted, and its depth diminished, so that ships of 300 tons can scarcely be admitted. The population of the borough of the old town in 1811, was 534 houses, 575 families, 278 of which were employed in trade and manufactures, and 2641 inhabitants. See Warner's *Account of Lymington*, and the *Beauties of England and Wales*, vol. vi. p. 181.

LYNCURIUM. See Electricity; and Beckman's *History of Inventions*, vol. i. p. 141.

LYMPH. See Anatomy.

LYMPHATICS. See Anatomy.

LYNN, Regis, or King's Lynn, is a sea-port, borough, and market town of England, in the county of Norfolk. It is situated ten miles from the British ocean, on the east bank of the river Ouse, which is here about as broad as the Thames at London bridge. It is about 1¼ mile long, and half a mile broad, and is divided into several parts, by four small rivers called Fleets, over which there are eleven bridges. A deep wet ditch, flanked by a strong wall, formerly defended by nine bastions, encompassed the town on the land side.

The town consists of two principal streets, and several smaller ones, which are well paved. Many of the houses are ancient and irregular; but there is a great number of well built and handsome houses, which have been recently erected. The church of St. Mary is a large and spacious structure, and has a nave with aisles, a choir with aisles, a transept, and two towers at the west end. The chapel of St. Nicholas is a neat old building, supposed to have been erected about the time of Edward III. It is 200 feet long, 78 broad, and 170 from the foundation to the top of the tower. The east and west windows are large and handsome. The exchange or custom-house is a handsome freestone building, with two tiers of pilasters. It was erected in 1683. The Tuesday market-place occupies an area of three acres, and is surrounded with some good houses. At one end of it is the market cross, erected in 1710, and encompassed with a handsome peristyle of sixteen Ionic columns. There are also in Lynn a theatre; a guildhall, which is an ancient building of stone and flint; commodious assembly rooms, the steeple of which is a famous sea mark; a grammar school, held in a building called the Charnel hall, and the remains of the monastery of the Grey Friars. The king's staith-yard, or quay, where the imported wines are landed and housed, is a handsome square with brick buildings, with a statue of king James I. in the centre. The town is supplied with water from the Gaywood river, by small canals about two or three miles long. The harbour is deep, but the anchorage bad, and it is capable of receiving about 300 vessels. It is difficult to enter, and is defended by a battery of heavy guns. The situation of the port, and its inland navigation, give it great commercial advantages. It is said to import annually about 100,000 chaldrons of coals, and 2000 pipes of wine. In return for these, it receives back for exportation corn and various manufactured articles. The annual duties of Lynn in 1784, exceeded those of all the English ports, excepting London, Bristol, Liverpool, and Hull. It carries on a considerable trade with Spain, Portugal, Holland, and the Baltic, and takes a share in the Greenland fishery. Among its other institutions, are two libraries, a work-house, a free school, a reading and spinning school, charity school, and alms-house, besides numerous benefactions. The population of the borough in 1811, was 2199 houses, 2530 families, of which 1576 were employed in trade and manufactures, and 10 259 inhabitants. See Bloomfield's *History of Norfolk*, and the *Beauties of England and Wales*, vol. xi. p 290

LYONS, anciently *Lugdunum*, a city of France, and capital of the department of the Rhone, is situated principally on a tongue of land lying between the rivers Rhone and Saone, about a mile above their confluence. A part of the town stands upon the heights and sides of Fourviere, on the south side of the Saone. The Rhone is crossed by two excellent bridges, the Pont de la Guillotiere, built of stone, and the Pont Morand, made of wood. The Pont de la Guillotiere, the elevation of one half of which we have given in Plate LXXXIII. was constructed in place of a bridge of wood which fell in 1190, when Richard, King of England, was passing over it with the army for the crusades, and is said to have been erected some time between 1244 and 1251. It had originally 20 arches, but they were reduced to 17; and, in the 16th century, it was widened by the addition of another bridge, bound to the old one by bars of iron. On the 11th of October, 1811, when crowds had crossed this bridge to celebrate a festival, they were prevented from returning by the guard, who meant to demand a contribution. The consequence of this was, that a dreadful crush and disorder took place, in consequence of which 238 persons perished. The sergeant of the guard was a few days afterwards broken on the wheel for this offence. The Saone is crossed with seven bridges, three of which, viz. the stone bridges of Tilsit, Serin, and Ainay, are new and beautiful, being built in the same manner, and the abutments being all sections of the frustrum of a cone. The Pont Mulatiere over the Saone, near its confluence with the Rhone, consists of 11 wooden arches, and 2 stone abutments. The Pont du Change, or Pont de Pierre, built of the stones of Roman monuments, has eight arches, and supports some houses on its northern end. It was built in 1050, by Humbert, Archbishop of Lyons, for the purpose of uniting the ancient with the modern town. It is about 627 feet long, from the great length of its approaches. The Pont de St. Vincent, built of wood, consists of three arches, and was built by Aubert, in 1715. The Pont Volant is a light wooden bridge, at which a small toll is paid. In the oldest part of Lyons the streets are very narrow, but the houses are lofty and commodious. In the newer parts of it, such as the square of Louis le Grand, and the streets situated on the quays of the Rhone, the houses are extremely elegant. The houses in the great square are four stories high, and those on the Rhone are sometimes eight, and commonly six stories.

One of the most magnificent public buildings in Lyons is the Hotel de Dieu, designed by M. Soufflot, and situated on the Rhone. This building, which has been left unfinished, has a portal with four Ionic columns. It receives annually 13,000 patients, and contains 1800 beds, all of iron, and has all the accommodations which are necessary in a well regulated hospital. The hospital of La Charité, situated also on the Rhone, is under the same administration as the other, with a good revenue of 400,000 francs. It is an immense building, without beauty, consisting of a great number of separate courts, with trees, each court having an arcade round it. The church belonging to it is in a very good condition. The Antiquaille, another hospital, is situated on the declivity of Fourviere.

The Hotel de Ville is reckoned, after that of Amsterdam, the most magnificent in Europe. It was begun in 1646, and finished in 1655, from the designs of Simon Maupin. The tower containing the clock is about 163 feet high. The entrance gate, the balcony, the vestibules to the court, the great stair, and the two statues in the vestibule, representing the Rhone and the Saone, are well deserving the notice of strangers.

The building of St. Pierrie, which forms the principal façade of the Place des Terreaux, is a large and beautiful edifice of three stories, with a quadrangular court. It contains a school of design, a chemical laboratory, a physical cabinet, the collection of pictures, and the museum of antiquities, under the direction of M. Artaud, an eminent antiquarian. The various societies also hold their meetings in this place.

The large building of the Lyceum and Public Library was begun in 1607, and the church in 1617; but neither of them was finished till 1653. The number of pupils was lately 200; but there is accommodation for 500 or 600. The library, which is under the charge of M. Delandine, is one of the best in Europe. It contains the magnificent editions of the Louvre; many precious MSS.; a collection of works, in 22 volumes, relative to the laws, &c. of China, printed at Pekin, and brought to Lyons by a Jesuit missionary; a MS. engraved on plates of ivory; a very extensive and curious collection of engravings; and two globes six feet in diameter. Among the other public establishments of Lyons are, the veterinary school, established in 1761; the cabinet of natural history; and the botanic garden, which occupies nearly 14 acres, upon the hill of the Carmelites. The cabinet was formed out of that of M. Pestalozzy, and given to the city before the Revolution, and of that of M. Tourette, purchased in 1797; and of other collections. The mint is a very large building, which was not long ago repaired with great care. The fly is composed of the cannon taken at Austerlitz. The building for the preservation of silk was begun in 1808. It stands near the church of St. Polycarp, and has a character suited to the purpose for which it was erected.

One of the most ancient churches in Lyons is that of St. Irenée, built on the tombs of the martyrs St. Epipoy and St. Alexander. The pavement of the upper church contains the remains of an inscription to the memory of 19,000 Christians, who suffered martyrdom under Severus. There is a vault in the subterranean church, which is said to contain the bones of the greater part of these martyrs.

The church of Ainay was founded in 1020, and was built on the same spot, and with the ruins of the ancient temple which the Lyonnais erected to Augustus. The sanctuary was paved in mosaic. It represented the Pope Paschal II. holding in his hand the figure of the new church, which he was about to consecrate, with several inscriptions. Only a few fragments of the mosaic remain. The ten granite columns were brought from Egypt. Two of these, next the altar, are 12 feet in circumference.

The church of St. Niziere is a mixture of Greek and

Gothic architecture, and was built in the 14th century, by Renouard. It has four flying buttresses on each side; and its portal, which was built in the 16th century, by Philibert Delorme, is a demi-cupola, with four fluted Doric columns. The circular window to the north of the nave is fine, and the roof is very grand. The statue of the virgin and child, by Couston, is much admired.

The church of St. John, which is now the metropolitan church, is situated on the north side of the Saone, at the foot of the heights of Fourviere. This church is a fine specimen of Gothic architecture, and contains several splendid paintings, most of which were standing unframed in the aisles, when we visited it in 1814. One of the chapels is highly ornamented, and has a small but curious circular window to the west. The windows of coloured glass in the nave are very fine and brilliant, but contain no figures. The one above the altar, and three circular windows, are very superb. There is a very curious clock in the north end of the transept, which an inscription states to have been injured by the Calvinist soldiers in 1561, but which was repaired, in 1598, by Nicolas Lippius, of Basle; in 1660, by Nourisson; and in 1783, by Charmy. It is nearly of the same kind as that of Strasburg, but has been neglected since the revolution. The portal of this church, which was finished under the reign of Louis XI. is very splendid. The church is flanked with four large towers, one of which contains one of the largest clocks in France. All the canons of this church had the title of count, and the king was the first canon.

The other churches of the middle age are, the church of St. Paul, the church of St. Peter, the church of St. George, and the church of St. Bonaventura, a large Gothic building.

The principal modern churches are those of Fourviere, situated on the heights of Fourviere, and commanding a magnificent view of the town of Lyons, of the vast plains of Dauphiny, and of the distant Alps, with Mont Blanc rising majestically above them all. The other churches are those of St. Just, of St. Polycarp, of St. Louis, of St. Chartreux, and of St. François.

Lyons is particularly interesting to the antiquary, from the number of curious antiquities which it contains. The remains of the Roman aqueduct, near the gate of St. Irenée, which extended for seven leagues, from the stream called Furens, near to the town of St. Etienne, to the gates of Lyons, where the water of that river was distributed to the town and the Roman camp. In accomplishing that vast undertaking, several hills were pierced, and arcades of prodigious height raised across the vallies. Many of these arcades still exist, in a state of excellent preservation, near the villages of St. Foy, Biaunand, Chaponost, and Brignais. The remains of a second aqueduct appear in the valley of Ecully, below Grange Blanche, which served to conduct the waters of the Mont d'Or to the mountain of Lyons. At Pollionay, Courzieu, and Argentiere, are the vestiges of a subterranean aqueduct, which brought to St. Irenée the waters of the Coise and the Brevenne; and there was a fourth aqueduct, which extended from Montluel along the Rhone, and terminated in the hill of St. Sebastian. This aqueduct was probably constructed after the burning of the town under Nero. The great aqueduct has been ascribed to Marcus Antoninus, and has been fully described by M. Delorme in his *Recherches sur les Aqueducs de Lyons*. Those of Ecully, Courzieu, and Montluel, which are daily going to ruins, deserve to be examined and described.

Among the reservoirs which receive the waters of the aqueduct, and which have been discovered in different parts of the town, the most considerable are those in the enclosure of the Ursulines of St. Just, and in that of the Antiquaille. The first of these, which is well preserved, is 45 feet long, and 44 wide, and has a wall eight feet thick. It is composed of a triple row of vaults built under ground, and covered with a cement which has acquired the hardness of stone. There are two conduits for introducing the water, and several holes for conveying it away. The second of these reservoirs is 100 feet long, 12 feet wide, and 15 feet high. It is covered with a hard and well polished red cement, and is cut into two unequal parts by a very thick wall. The red colour of the cement induced many antiquarians to believe that this had been a reservoir for wine; but M. Mongez ascertained that the red colour belonged to the cement; and it is now universally admitted to have been destined for the reception of water.

The remains of an ancient theatre, supposed to have been erected by Claudius for the combats of gladiators and wild beasts, still exist in the vineyard of the ci-devant Minimes, on the sides of Fourviere. The subterraneous vaults only exist, and received the name of *Grottes des Sarrasins*, probably from the theatre having been destroyed by the Saracens or Moors of Spain, who ravaged Lyons in the 8th century.

The Mosaics are among the most interesting antiquities of Lyons. A very well preserved mosaic was discovered in 1676, in the descent of Gourgillon, in the garden of the house of Vendome. The pavement is 20 feet long, and 10 feet wide, composed of different compartments, well executed. In the square picture, in the centre of the pavement, there are four figures. One of these, which is without feet and arms, is supposed to be Hermathene, or Mercury and Minerva united. The second and third are supposed to be Love and Pan; and the fourth a divinity performing the functions of Gymnasiarch.

In the garden of M. Macors, on the ramparts of Ainay, there are other two mosaics in very excellent preservation. The first, discovered on the 18th February, 1806, exhibits an ancient chariot race; and the second represents Meleager, the conqueror of the boar of Calydon, at the moment when he is about to offer the skin to Atalanta. Two other mosaics have been found in the same garden, and in that of the brewery of M. Graff, behind Ainay. M. Artaud, the learned and ingenious director of the museum of Lyons, to whose politeness the English have been deeply indebted, has engraved these remains of antiquity, and is about to publish them in a detailed account of the mosaics of the south of France.

In describing the church of Ainay, we have already noticed the granite columns. Each of the large columns were intended to support a statue of Victory. They were formerly 26 feet high, but were cut through the middle, and now form the four pillars which support the vault of the choir. Above the great entrance to the church is a marble bas-relief, representing three divinities with fruits in their hands.

The splendid tables of bronze, which the Emperor Claudius left to his native city of Lyons, as a testimony of his affection, were dug out of the hill of St. Sebastian in the year 1528. These tables contain part of a speech which Claudius pronounced when Lyons was a Roman colony, under the name *Colonia Claudia*, and of the decree which followed. These bronzes, in a state of high preservation, are now placed in the museum.

In the upper part of the botanic garden are the foundation of a vast circular amphitheatre, where vestiges of walls and vaults, and also medals, have been found. Some antiquarians have thought that it was a Naumachia, and that the vaults were for conducting the water; but the general opinion is in favour of its having been an amphitheatre.

The museum of Lyons is perhaps one of the most interesting in Europe, and has lately been arranged and described by M. Artaud, who has published an account of the different objects which it contains. The paintings of the museum are deposited in the Sallon des Fleurs, which contains 14 pieces; in the great gallery, which contains 83 pictures; in the *Salle des Antiques*, which contains 10, besides 24 of inferior importance, which are placed in the halls of administration. The ancient inscriptions, which M. Artaud has described, amount to 63. The cabinet of antiquities is composed of the debris of that of the city library, which was dilapidated during the revolution—of a great part of that of M. Migieu, which was purchased by the Count de Sathonnay, mayor of the city —and that of M. Tempier of Nismes, and of several other individual collections. The hall which contains the antiquities, and also that of the gallery of pictures, were constructed from the designs of M. Gay, and are together 222 feet long, and 32 wide. The ceilings were painted by M. Latila. The cabinet of antiquities contains 172 pieces of Egyptian antiquities; 29 Indian antiquities; the two bronze tables of Claudius; 26 Tuscan figures in bronze; 14 Gaulic antiquities; 21 Greek vases; 92 Roman antiquities; 185 bronze figures, and other objects; 21 imitations of antique bronzes; 57 modern bronzes; 7574 ancient and modern medals, to which M. Artaud has added 978 medals, 100 of which have, on the reverse, the Altar of Augustus, so that the actual number of medals is 9560; 242 ancient lamps, glasses, &c. beside a number of other curiosities.

Among the private collections of antiquities, that of M. Artaud is the most important, and contains a number of interesting objects that were discovered, in 1800, in one of the fauxbourgs of Montpelier, and of which M. Mongez gave an account of the institute in 1803. The other private collections belong to M. Gay, La Romain, and M. Mercier.

The Academy of Lyons was founded in 1700; and after its dispersion by the Revolution, it was re-established in 1800. The Society of Medicine was founded in 1792. The Society of the Friends of Commerce and the Arts was established in 1805; and the Society of Pharmacy in 1806. There is also here a Society of Agriculture, Natural History, and the useful Arts.

Among the individual buildings of Lyons, the Archiepiscopal palace and the Manecanterie, are the most important. The palace was built by the Cardinal de Bourbon in the 15th century, and restored by the Cardinal de Teucan, after the designs of Soufflot. Though irregular in its exterior architecture, its interior accommodation is highly magnificent. The view, from the southern terrace, of the Saone running below in a circular sweep is extremely fine. The Manecanterie is a sumptuous edifice, erected for the accommodation of the clergy of the cathedral. Its foundation was laid in 1768.

There are two theatres in Lyons. The largest was built, after the design of Soufflot, in 1755 and 1756. It is capable of containing 2000 persons, and is in every respect worthy of such a city. The theatre of the Celestins is inferior in size and decoration. Of late years great numbers of baths have been erected in Lyons, and those of the Sieur Reybaud, on the Rhone, opposite the Lyceum, from the design of M. Gay, are the most ingenious and the best frequented. They stand upon a vessel 160 feet long, and 32 feet wide, and are highly deserving the examination of strangers.

Before the year 1772, the Rhone and the Saone joined their waters near Ainay. The sculptor, M. Perrache, formed the wild idea of removing their confluence to the village of Mulatiere, and, in 1770, he obtained letters patent for this purpose. A company was formed to execute this great enterprize. A new bed was excavated for the Rhone, which was compelled to take another direction, by a magnificent causeway about 1500 toises, or nearly a mile and three-quarters long, planted with lofty Italian poplars, and forming a splendid continuation of the quays of Lyons. The city of Lyons offered to the government the greater part of the land which was thus created, as the site of an imperial palace. The offer was accepted, and decrees were passed, in 1809 and 1810, to carry this great work into effect. The subsequent disasters, however, which befel France, have prevented the execution of this project; and it is not likely that Lyons will be soon honoured with a royal residence.

In our article on FRANCE, we have given an account of the silk manufactures of Lyons before the Revolution. From the changes which have since taken place in Europe, its manufactures were ruined; but the restoration of peace has again revived them, and we have no doubt that Lyons will soon reach that high rank which she formerly possessed as a manufacturing city. Before the Revolution, there were 22,000 persons employed in the silk manufactures, and in 1801 there were scarcely 5000. In 1804, when M. Millin visited Lyons, he states, that the number of looms were reduced from 15,000 to 7000, and that these 7000 were not all employed. The silk manufactures were founded by M. M. Turquet and Nariz. There are also at Lyons manufactures of lace, and different cotton, linen, and woollen stuffs. There are four annual fairs, in January, May, August, and November, which are much frequented.

The city of Lyons is said to have been founded in the year of Rome 711, about 40 years before the Christian æra, by Lucius Manutius Plaucus. About the same time Marcus Antoninus constructed the lower aqueduct. Forty-six years after this, Lyons was considered as the metropolis of Gaul. Augustus then appeared at Lyons, and the sixty nations erected to him the famous altar at the confluence of the two rivers. Some time afterwards, the city was consumed by fire, in the reign of the Emperor Claudius. Nero rebuilt it, and Adrian and Antoninus loaded it with acts of kindness; and, in honour of the last of these monarchs, the city raised to him the altar of the Cæsars, *Ara Cæsarum*, which was formerly seen at St. Just. About this time Christrianity was established at Lyons, by the zeal of St. Pothier, who perished, with forty-eight of his disciples, in a persecution which was excited against him. St. Irenée, who succeeded him, suffered the same fate, with 19,000 Christians, in 203, under the Emperor Severus. The city was laid waste by his troops; but, in the fourth century, it gradually recovered. At the end of the fifth century, Lyons came into the hands of the Dukes of Burgundy, who fixed their residence in it. In the sixth century, it came into the possession of the kings of France. In the eighth century, it was ravaged by the Saracens. When Lothaire retired to the Abbey of Treves, Lyons became the capital of the kingdom, which he gave to his son Claude. In 879 it was taken by Bozon, but was restored to France by Louis and Carloman. In 954, Lothaire II. gave the city as a dowry to his sister Matilda, when she married Conrad, king of Burgundy, beyond the Jura. In 1228, the new town was built between the Saone and the Rhone. In 1565, it was surprised by the Calvinists. Its sufferings during the Revolution have been noticed in our article FRANCE.

The population of Lyons was supposed to be 150,000 before the Revolution. More recently it has been stated at 109,500 by Chantreaux, while others make it only about 90,000. East Long. 4° 49′ 24″. North Lat. 45° 45′ 48″.

For further information respecting this interesting city, the reader is referred to Millin's *Voyage dans les departments du Midi de la France*, tom. i. p. 405—*Tableau des Prisons de Lyon*, par M. Delandine, Paris, p. 539; *Lettres à ma Fille sur mes promenades à Lyon*, 4 vols. Lyons, 1810; *Description de Curiosités de Lyon*; *Histoire du Siege de Lyon, depuis* 1789 *jusqu'au* 1796, 1797; and the various works of M. Artaud, descriptive of the antiquities of the city.

LYSANDER. See ATHENS, GREECE, and LACEDÆMON.

LYTTELTON, GEORGE, (afterwards Lord Lyttelton,) was the eldest son of Sir Thomas Lyttelton, Bart. of Hagley, in Worcestershire, where he was born in the month of January, 1708-9. He was educated at Eaton, where he distinguished himself by his school exercises; and afterwards repaired to Christ-Church College, Oxford, where he displayed the same proficiency in classical literature, and shewed considerable poetical talents. His verses on *Blenheim*, his *Progress of Love*, and his *Persian Letters*, were all written when he was very young, and, indeed, bear the strong impression of youth.

In the year 1728, he set out upon a tour to the continent, and visited France and Italy. During his residence abroad, he wrote a poetical epistle to Dr. Ayscough, his Oxford tutor, and another to Pope. On his return to England, in 1730, he obtained a seat in parliament, as the representative of the borough of Oakhampton; and soon distinguished himself as one of the most ardent opponents of the administration of Sir Robert Walpole, although his father, who was one of the Lords Commissioners of the Admiralty, voted, of course, with the court party. For many years the name of George Lyttelton appeared among the minority in every important debate in the House of Commons; and he zealously concurred in all the measures adopted by Pulteney, Pitt, and other leaders of the opposition. When Frederick, Prince of Wales, formed a separate court of his own, in 1737, Mr. Lyttelton was appointed his secretary, and was supposed to have great influence in the direction of his conduct. Mallet was made under-secretary, with a salary of 200*l*. and Thompson received a pension of 100*l*. a year.

In 1741, he married Lucy, the daughter of Hugh Fortescue, Esq. of Devonshire, by whom he had a son and two daughters, and with whom he appears to have enjoyed the highest degree of conjugal felicity. But this lady died in child-bed about five years afterwards; and he endeavoured to solace his grief, by writing a monody to her memory, which is reckoned one of the best of his poetical works. In 1749, he entered into a second marriage with the daughter of Sir Robert Rich; but her conduct was so little to his satisfaction, that they separated a few years after by mutual consent.

Upon the overthrow of Walpole's administration, Mr. Lyttelton, in 1744, was appointed one of the Lords of the Treasury; and from that time he was engaged in supporting the measures of his party. He spoke with ease and fluency; but his oratory was distinguished rather by elegance and good sense, than by any remarkable strokes of genius. Politics, however, did not wholly engross his thoughts. In early life, he had been led to entertain doubts of the truth of Christianity; but having applied himself seriously to the study of the evidences, his inquiry ended in conviction. His *Dissertation on the Conversion of St. Paul*, which was printed in 1747, is considered as a very masterly performance, to which, Dr. Johnson observes, infidelity has never been able to fabricate a specious answer.

In 1751, he succeeded, by the death of his father, to the baronet's title, and a large estate. He displayed his taste for rural ornament at his mansion of Hagley, which he adorned with great elegance and much expense, and rendered one of the most delightful residences in the kingdom. Having, at the same time, continued his activity in parliament, he was first appointed cofferer of the household, and privy counsellor, and afterwards chancellor of the exchequer. This last office, however, requiring some qualifications which he did not possess, he soon resigned it to Mr. Legge. In the following year, he made an excursion into Wales, of which he gave an account to Archibald Bower, the author of the *Lives of the Popes*; a man of whom Lyttelton conceived an opinion more favourable than he seems to have deserved, and whom he continued to patronise after he had been abandoned by all his other friends.

On the dissolution of the ministry, in 1759, Sir George went out of employment along with his colleagues; but his past services were recompensed with a peerage, and he accordingly took his seat in the House of Lords, by the title of Baron Lyttelton of Frankley, in the county of Worcester. From this time he devoted himself chiefly to literary pursuits. In 1760, he published his *Dialogues of the Dead*, a work abounding in good sense and sound morality, which was much read, and well received by the public, but which possesses too little vivacity and interest for a publication of that kind. His last literary production was his *History of Henry the Second*, a work containing the elaborate result of the researches and deliberations of twenty years, and which was published at length with such anxiety, as manifested the importance which the author attached to it, as well as his expectation of future fame. The printing was begun in 1755, and concluded in 1771.

His lordship died of a lingering disorder, which he bore with pious resignation, in the month of August, 1773, at the age of 64. He has been complimented in verse by Pope and by Hayley. From the narrative we have given of his life, it will be perceived that his talents were respectable, and his character estimable. His verses still preserve a place among the select productions of our minor poets; yet, as Dr. Johnson remarks, they have nothing to be despised, and little to be admired.

The miscellaneous works of Lord Lyttelton were published after his death, by his nephew G. E. Ayscough, Esq. in one volume 4to. See Johnson's *Lives*, and Aikin's *Gen. Biog.* (z)

M.

MACAO, an island on the coast of China, containing a Portuguese town and settlement well known to Europeans. The island is called Ama-gao by the Chinese, this name being derived from an idol Ama, which had a temple here. It is scarcely a league in length, by about half a league in breadth, of unequal surface, and scantily supplied with water. A harbour is formed by Macao and a neighbouring island; but it is shallow, and exposed to winds, rendering it insecure, and it is, besides, embarrassed by other dangers; but being at the mouth of the river descending from Canton, the only sea-port of the Chinese empire open to Europeans, and there being no other territory than Macao belonging to them throughout its vast extent, it becomes of greater consequence.

The soil of this island is in general arid; the hills are bare, and nothing but a small portion of the surface is under culture. There are a few gardens, one of which is of considerable extent, and full of trees, having been occupied, along with the dwelling that it belongs to, by the English, who have laid it out according to their national taste.

The town, forming an amphitheatre, occupies an elevated and irregular surface, and is defended by several fortifications and a wall; but it is not at present esteemed a place of strength. Its streets are paved, and have a covered kennel in the middle, whereby they are speedily dried after rain. At the southern extremity there is a Chinese temple, consisting of three distinct buildings, one above another, accessible only by steps cut out of the solid rock, the whole being overshadowed by trees. Macao is divided into three parishes, which contain a cathedral, and twelve churches or chapels. There are five monasteries, which were lately inhabited by 21 monks, and a convent with 42 nuns. Of all these, the churches of St. Paul and St. Joseph alone demand notice. The former belonged to the French Jesuits, who received the clock, which is still to be seen there, from Louis XIV.; the latter is smaller, but well proportioned. In the senate-house, which is built of granite, and two stories high, are several columns of the same substance, with a Chinese inscription, recording the solemn cession of the island by the emperor. Little can be said in commendation of the houses of the town. They consist of a single storey, with the interior disposed as best adapted to a hot climate. Most of the Europeans lodge on an extensive quay, where they have an agreeable promenade, tempered by the sea breeze; the remainder occupy the western part of the town, whence they enjoy a view of the harbour and a circular island, which, of all the surrounding objects, being alone covered with perpetual verdure, is thence called *Green Island.* At this extremity also is a garden, with a recess in the rock, wherein Camoens is believed to have written the Lusiad.

The total population of the town of Macao is computed at 12,000 or 15,000 by Krusenstern, but was fixed by more accurate calculations at 12,371 by M. de Guignes. The former observes, that the Chinese have so completely taken possession of it, that it is rare to meet any European in the streets, with the exception of priests and nuns; and this can be easily understood, from the following division, which M. de Guignes gives of the inhabitants. *Portuguese* in the civil government 10; military 165; ecclesiastics 93; others 3103; *Chinese* 8000: total 12,371. The military are mulattoes of Macao and Goa, while only some of the officers are Europeans.

As the Portuguese disdain to exercise any handicraft professions, all the shops are kept by their more prudent neighbours. The richer part of them, therefore, are concerned in commerce, while the poorer engage in a sea-faring life. This was once a very flourishing place, carrying on a considerable traffic with the Chinese empire, Japan, and other parts of eastern Asia; but it has now totally decayed, and its decline has been ascribed to the cessation of intercourse with Japan. Its eastern trade lately consisted in a single vessel sailing to Goa, on the coast of India; another to the island of Timor; one or two for Bengal; the like number for Manilla; and three or four for Cochin China. The commerce with Europe was restricted to the arrival of one or two ships from Lisbon, with cargoes of Brazil tobacco, which were replaced by Chinese commodities. It is said that the number of Portuguese resident here has greatly diminished.

The town is enlivened by the presence of strangers, to whose expenditure its support is much indebted, and particularly from the resort of the English in their extensive commerce with China. But with them the Portuguese have little intercourse, as they chiefly associate among themselves, and the women, in particular, live very retired. The latter dress in black, with large mantles, disguising them completely even from their nearest relations. Those of distinction travel in palanquins; but others, of limited fortune, content themselves with a low square *cage*, which is literally so designed in their language, and is of such dimensions as to excite astonishment in the spectator how such restraint can be endured. The amusements of the inhabitants are exceedingly limited, and the education of both sexes very confined. All are extremely devout, especially the females, who for the most part carry rosaries.

Both the Portuguese and Chinese exercise authority in the civil government of Macao. The former are under the rule of a governor, who holds his office for three years; and being one which it is difficult to discharge, none but experienced persons are appointed to it. Judicial matters are under the controul of three senators, the first of whom ranks next to the governor; nor is the latter altogether independent of him. They hold a court twice every week, wherein the governor presides. Macao is an episcopal see, and the bishop enjoys much influence and prerogative. On the death of one of the governors, this ecclesiastic temporarily occupied his place, during which time the Chinese proposed to render Macao the port for receiving all the vessels usually ascending to Whampoa. Such a measure would have proved the source of infinite prosperity to the settlement, but it was imprudently rejected, from the apprehension of introducing heretics. Neither the morals nor the religion of the inhabitants have profited by the refusal, and their finances have declined. The Chinese are under the jurisdiction of the governor of another city, who is entitled to a salute when he enters the town; and they have two temples in the island for performance of their religious rites. When disputes occur between them and the Portuguese, they arrest the supply of provisions, as the island is unproductive, and depends on an external market; by which means the latter are compelled to obtain an accommodation by money. However, when this incident once happened, the governor, who had a stock sufficient for two years, disregarded their threats, and followed those plans which appeared to himself most expedient.

The earliest European traffic with China was established by the Portuguese, who are said to have frequented the port of Ning-po, or Siampo, in the first years of the fifteenth century. In 1517, the viceroy of Goa sent eight vessels from that settlement with an envoy, whose prudence was totally defeated by the conduct of the maritime commanders, and a serious difference arose, which terminated in his detention. The Portuguese, however, having rendered signal service to China in repelling a Japanese pirate, whom they killed in 1563 at Macao, the emperor ceded this island to them in perpetuity, and here they built the town in 1585. It has been since frequently threatened by the European powers, according to their contests with Portugal; and the British were to have landed forces, with the governor's consent, to take possession of the settlement, when, on the same day, intelligence of the peace of 1802 was brought by a Spanish frigate from Manilla. The Chinese, who were greatly alarmed by the preparations, had their fears renewed on another occasion; and the Portuguese are accused of always exciting jealousies regarding the designs of the British embassies. Lat. 22° 11′ 46″. N. Long. 113° 21′ E. See De Guignes's *Voyages*, tom. ii. p. 148. tom. iii. p. 176; *Atlas*, pl. 94; Krusenstern's *Voyages*, vol. ii.; Staunton's *Embassy*, vol. ii.; Horsburgh's *Sailing Directions*. (*c*)

MACASSAR, or Mungkusar, is the name of the principal settlement of the Dutch in the island of Celebes, situated on the west side of the island. The town of Macassar, called Vlaardingen, is situated in an extensive plain, which reaches to the foot of a range of high mountains, about 8 or 10 Dutch miles to the eastward. This plain is covered with rice fields and pasturage, and is irrigated by small canals taken from the streams which descend from the mountains. The streets of the town cross each other at right angles, and are in the direction of the four cardinal points. Most of them are broad, and contain tolerably good houses. The orphan-house, which is large, but in a ruinous state, stands at the end of one of them. The Chinese live together in one street, which is named after them. The town is defended by palisades; and a constant watch is kept at the gates, which are always closed at night. To the south of the town is a row of buildings, where the house of the governor stands. The Bougeness and Malay Campongs, or quarters, are not far from it. The Campong Baro, where the greater part of the natives and a few of the Europeans reside, is south of the fort, and contains a few brick houses. The church, which has been rebuilt within these few years, is a neat and airy structure, and is capable of containing about 200 persons. The seat of the governor is wholly gilt, and is under a canopy opposite to the pulpit. Between the Campong Baro and the Fort is the burying-ground, where every European of any consideration has a separate grave, with a tomb-stone.

Fort Rotterdam, the plan of which has been published in the Lives of the Governors General of India, and still remains exactly the same, was built by the natives, with the assistance of the Portuguese. It is about 800 feet from the beach opposite to the road, whose pier extends into the sea, for the purpose of unloading vessels, and where there is a depth of 15 or 16 feet of water. The walls of the fort are built of freestone, and are high and strong.

The road of Macassar is one of the most beautiful in India, and is defended by numerous small islands and sand-banks from almost every wind.

In 1777, the Dutch establishment here consisted of 57 persons in the civil service, 3 ecclesiastics, 13 surgeons and assistants, 27 artillerymen, 178 seamen and marines, 502 soldiers, and 72 mechanics, making a total of 852 Europeans. Fort Rotterdam is situated in East Long. 119° 20′, and South Lat. 5° 10′. Macassar is also the name of a kingdom on the south-west coast of the island of Celebes. About the middle of the 17th century the power of the state was at the highest; but it was entirely subverted by the Dutch in the year 1778. See Stavorinus's *Voyages to the East and West Indies*, vol. ii. p. 186; Wurmb's *Description of the Island of Celebes, or Macassar*, translated from the Dutch, and published in the *Philosophical Magazine* for May 1800, vol. vi. p. 289; and a *Description of the Islands of Java, Bali, and Celebes*, by John Craufurd, Esq. now in the press. See also Celebes.

MACCHIAVELLI, Nicholas, a celebrated historian and political writer of Italy, was born of a patrician family at Florence, in the year 1469. Having engaged in the business of public life, he was suspected of being an accomplice in the conspiracy of the Soderini against the Medici; but he endured the torture without confession, and was set at liberty. He afterwards became secretary and historiographer to the republic of Florence; and was employed in various embassies to King Louis XII. of France; to the Emperor Maximilian; to the college of cardinals; to Pope Julius II.; and to other Italian princes. During the latter period of his life, he is said to have given himself up to irreligious principles. He died in the year 1527.

Machiavel wrote various pieces in prose, poetry, and the drama. His poetical and dramatic productions are not much esteemed; and his reputation, therefore, is founded entirely upon his historical and political writings. Among these, his *History of Florence*, in eight books, comprising the period from 1205 to 1494, is considered as a most valuable performance, and the earliest of the better Italian histories. It is written with great purity and elegance of style, and much skill of composition, although rather oratorical and declamatory. His *Discourses upon the first Decade of Livy*, are replete with just and profound observations on the principles of popular government. The treatise *Del Principe* is the most curious of all his works, and has occasioned much controversy with regard to the author's principles and motives. His perfect prince is the most unprincipled tyrant, and the maxims of government he inculcates are those of arbitrary power, and the most profligate policy. Yet the intentions of the author are by no means obvious; and some have thought, that he only delineated the character and conduct of a tyrannical prince in order to excite the abhorrence of mankind. The *Life of Castrucio Castracani*, the hero of Lucca, has more of the character of a romance than of an historical narrative.

The works of Machiavel were collected in 1550, in two volumes 4to. and have been frequently reprinted. See Tiraboschi, Moreri, Aikin's *Gen. Biog.* and *Biog. Dict.* (z)

MACCLESFIELD, a large and manufacturing town of England, in the county of Chester, is situated on the descent of a steep hill, and consists of three principal streets and some smaller ones. The best street, which contains very excellent houses, is about one and a half mile long.

Macclesfield contains two churches, and five places of worship for the dissenters. The old church, founded by Edward I. in 1279, has undergone several alterations and repairs; and the new church, built by the late Sir Charles Roe, in 1775, is an elegant building, adorned with a neat pinnacled tower. In the chancel there is a handsome marble monument, by Bacon, erected to the memory of the founder, who died in 1781. These two churches are only chapels of ease to the parish of Prestbury. There is here a spacious free grammar-school, founded by Edward VI. and three alms-houses, for the maintenance of poor widows.

In the street called Buckwell-gate, are some remains of a mansion of the Dukes of Buckingham. The town is well supplied with water from a fountain on Macclesfield common.

The great trade of Macclesfield for a long time consisted in wrought buttons, made of silk, mohair, and twist; but it is now celebrated for its cotton manufactures. It has also a manufactory of fustians, linen cloth, &c.; 30 mills for the throwing of silk for the weavers, and making sewing silk; and also an extensive work for smelting and making copper and brass. This work is situated on an extensive common, east of the town, where there is a large colliery, with large seams of coal rising alternately above each other. From the quantity of stone and slate in the neighbourhood, buildings are erected at very little expense. There is also an extensive brewery in the neighbourhood.

The population of Macclesfield, in 1811, was 12,299; and the number of inhabited houses 2,518. See the *Beauties of England and Wales*, vol. ii. p. 257.

MACDUFF, a sea-port town of Scotland, in the parish of Gamrie, and county of Banff. Before the year 1732, it contained only the huts of a few fishermen, with a small sandy creek for the boats; but it now contains several well laid out streets. The town belongs to the Earl of Fife, who has laid out more than 6000*l.* in improving the harbour, which is now one of the best in the Moray Firth. About 10 or 12 vessels belong to the town, which are employed principally in the Baltic and London trade. As Macduff is at some distance from the established church, Lord Fife has erected a neat chapel of ease, and given a suitable salary to the clergyman. There is a mineral spring at Farlain, not far from the town. The number of houses is above 300, and the population above 1200, the greater proportion of whom is engaged in the extensive fisheries established on the coast.

MACEDON, or **Macedonia**, in ancient history, was a kingdom in Greece, bounded on the west by the Ionian sea, on the north by the Scardian mountains, and the river Strymon, which separated it from Illyricum and Thrace; on the east by the Ægean sea; and on the south by Thessaly and Epirus. According to the best maps of the country, it lies between 40° and 42° of north latitude, and between 37° and 42° of longitude; extending from north to south about 160 miles, and from east to west about 220. After the boundaries of the kingdom were extended towards the east, as far as the river Nestus, which took place in the reign of Philip, the father of Alexander, the whole region was divided into three provinces, whose boundaries were in some measure marked out by nature. Pangaeno, a mountain situated near the source of the river Nestus, gave its name to the province which lay on the north-east, famous in the annals of fiction as the scene where Orpheus exhibited the wonderful powers of his lyre. Chalcis was the name of the middle region; which being bounded on the west by the gulf of Thermæ, and on the south and east by those arms of the Ægean sea which penetrate far into the country, was well calculated for inland navigation, whilst the fertility of the soil supported a numerous population. The southern province was called Pieria; extending along the western shore of the gulf of Thermæ, to the confines of Thessaly and Mount Pindus, it opened up a scene of such variegated beauty, that its flowery plains, its shady groves, and its crystal fountains, were supposed to lead the minds of the inhabitants to retirement and study, and to afford to the Muses their most delightful habitation, from which circumstance they were denominated Pierides. But it was not merely this province that was beautiful; the whole region was finely diversified with mountains, hills, rivers, and woods, admirably adapted either for pasturage or agriculture; and on the sea-coast the grounds were remarkably fertile, abounding in corn, wine, oil, and indeed every production which can minister to the wants and the happiness of the inhabitants. The air was pure, sharp, and uncommonly salubrious, not only from the variety of hill and vale which marked its surface, but from the nature of the climate, being situated in the middle of the temperate zone. The mines of Macedonia were famous in ancient times, and were the principal source of that wealth which Philip employed in making preparations for his own designs, and for those of his son Alexander. Almost every kind of metal was found in the country, but especially gold, which, in considerable quantities, was collected from the sand, but chiefly from the mines. The whole country being bounded on the east and on the west by the Ægean and Ionian seas, and being intersected by gulfs, lakes, and rivers, was admirably adapted for commerce, either at home or abroad; whilst the woods, which grew in the northern parts of the kingdom, afforded all the materials for ship-building; but the genius of the people, long accustomed to war, though solicited by these advantages, seems not to have improved them to the peace and prosperity of the nation. The mountains, Pangæus, Hæmus, Athos, and Olympus, reared their woody summits to the clouds in this region, and are associated, in the recollections of every cultivated mind, with the noblest productions of the Grecian muse. The rivers Drilo, Pangasus, Apsus, Aliacmon, Axius, and Strymon, intersected the country in every direction, and gave fertility to the fields. Agaia, or Edessa, was the ancient metropolis of Macedon; and though we must pass over many cities of considerable magnitude, yet we cannot exclude from this brief account, Pydna, the capital of Pieria, in which Cassander barbarously murdered Olympias the mother, Roxana the wife, and Alexander the son, of Alexander the Great. Thessalonica, now called Salonichi, the most considerable city of Macedonia at present, and formerly remarkable as being the place where St. Paul founded a Christian Church, to which he addressed two of those epistles which form a part of the Scriptures: and Pilla, the birth-place of Philip and Alexander, and rendered famous by the tomb of Euripides, the most pathetic of the Greek tragic poets, who is said to have been buried in its vicinity.

When we inquire into the early history of this country, we are lost in the depths of antiquity. It has been said that Chittim, the son of Javan, first migrated into this region, gave it his name, and supplied it with inhabitants. In process of time, however, it was parcelled out into a number of small independent states, which, though they had their respective kings, resembled each other in manners, in religion, and in government. Æmathius, the monarch of one of these states, either by his virtues or his military achievements, gained such an ascendant, not only in his own dominions, but in those of the neighbouring princes, that he succeeded in imposing upon the whole country the name of Æmathia, which has transmitted, through the surrounding darkness, his own to our times. In a succeeding age, Macedo, said to be a descendant of Deucalion, deprived his predecessor of that glory, and by the superior splendour of his abilities, succeeded in changing the name of the country into that of Macedon, which it still bears. But the praise, if praise it may be called, of conducting a band of daring adventurers into Macedon, and of reducing its petty states under subjection to his own power, belonged to Carenno, a native of Argos, who claimed his descent from Hercules, and who, about 800 years B. C. established the first permanent dynasty over the whole territory. The page of ancient history is inscribed with the names, and sometimes feebly illumined with the exploits, of a continued succession of kings, from Carenus, till the full blaze of the Macedonian glory burst upon the world, during the reigns of Philip and his son Alexander. The military achievements of the latter not only accomplished a most extensive revolution in the political world at that period, but gave an impulse and an energy to the powers of the human mind; and a principle of change and of progressive improvement to the civil and moral institutions of the world, which have not yet spent their force, nor ceased to operate; the effects of which, to a philosophic eye, must appear visible along the annals of the world, from that period to the present day. But the limits which are prescribed to us will not permit us to enter upon the history of this dynasty, which is incorporated with that of GREECE and of PERSIA, to which we must refer our readers. We may mention, however, that the kingdom of Macedon, which at one period threatened the independence of the most powerful nations in the east, was at last completely overthrown upon the field of Pydna; where Persius, and the army which he feebly supported, yielded to the superior genius of Æmelius Paulus and the Romans; and the country which had aspired to the glory of conquering the world, was degraded into a petty province of that empire. Bajazet, the Turkish Sultan, in the year 1357, wrested it from the grasp of the degenerate Romans, and it still groans under the yoke of the court of Constantinople. In manners, in religion, in laws, and in government, the Macedonians resembled the other dynasties of Greece, where the sovereignty of a monarch was acknowledged; and hence it is only necessary here to state, that full information on these subjects will be found under that article.

MACHINERY. See HYDRODYNAMICS, MECHANICS, and STEAM ENGINE.

MACKENZIE, SIR GEORGE, an eminent lawyer and miscellaneous writer, was born at Dundee, in 1636. After studying at the universities of Aberdeen and St. Andrew's, he was sent, at the age of 16, to Bourges in France, where he spent three years in the study of the civil law. Having been admitted to the bar upon his return to Scotland, he was distinguished by his talents and eloquence; and was appointed, in 1661, to plead the cause of the Marquis of Argyle, who was impeached for high treason. Although he gave great offence by the boldness and zeal which he displayed in behalf of his client, yet he was soon after raised to the rank of a judge in the criminal court; and, in 1674, he was knighted by the King, and made King's Advocate and one of the Lords of the Privy Council of Scotland. During the political troubles which then agitated the country, it was necessary that the public prosecutor should resort to measures of occasional severity; and, however mildly such disagreeable functions could be discharged, the clamour of one party must necessarily have been raised against them. Sir George, however, did not temper his severity with much mildness; and we fear that the title of the "blood-thirsty advocate, and the persecutor of the saints of God," was, to a great degree, merited, by the cruelties which he exercised against the Covenanters. Upon the abrogation of the penal laws by James II. Sir George Mackenzie resigned his situation as Lord Advocate. He was, however, restored soon after, when the king changed his measures; and he held his office till the Revolution. He opposed in council the proposed address in Scotland to the Prince of Orange, on his landing in 1688; and he also wrote a memorial to that Prince, exhorting him to adhere to the terms of his declaration. At the Convention of the Estates, he opposed warmly the declaration of a vacancy in the throne, and the election of William; but when he saw that such an opposition was ineffectual, he quitted all his employments in Scotland, and resolved to spend the remainder of his life in the university of Oxford. He arrived in that city in September, 1689, and was admitted a student by a grace passed on the 2d of June, 1690. In the following spring he went to London, where he died, in May, 1691.

Sir George Mackenzie was the author of various works, legal, political, and literary. The following are the most important. 1. A Discourse upon the Laws and Customs of Scotland, in matters criminal. 2. Ideæ Eloquentiæ forensis hodiernæ, una cum actione forensi ex unaquaque Juris parte. 3. The Institutes of the Laws of Scotland. 4. Observations upon the Acts of Parliament. 5. Jus Regum; or the Just and Solid Foundation of Monarchy in general, and more especially of the Monarchy of Scotland. 6. Observations on the Laws and Customs of Nations as to Precedency, with the Science of Heraldry as part of the law of Nations; and a Defence of the Royal Line and Antiquities of Scotland. 7. Reflections on the advantages and disadvantages that would happen by an incorporating Union between England and Scotland. 8. Aretino, or a serious Romance. 9. Religio Stoici. 10. A Moral Essay on Solitude. 11. Moral Gallantry. In addition to the above works, he wrote also a play, and several poems and lesser pieces.

Sir George Mackenzie had the honour of founding the Advocate's Library in the year 1680. He left behind him a MS. history of Scotland from the year 1660, which was recently found by the Rev. Dr. M'Crie. See Blackwood's *Magazine*, vol. i. p. 273.

MACKYNLETH, a market town of North Wales, in the county of Montgomery, is situated at the confluence of the rivers Dulas and Dovey. It is generally supposed to be the *Maglona* of the Itinerary. It is a neat, regular, and well-built town, and has a superior appearance to most of those in North Wales. Its only public buildings are a white-washed church, and a plain unadorned town-hall. The ancient senate-house, where the parliament of Owen Glendower was held in 1402, is now a stable, adjoining a butcher's shop; but it has a spacious entrance doorway, which evinces the importance of its original destination. The inhabitants of the town are chiefly employed in handicraft business. A tannery is carried on to a considerable extent, and also the manufacture of flannel, and what are provincially termed Webs, and also Welsh plains, or cottons, which are a coarse sort of white thick cloth, formerly exported in considerable quantities. See Pennant's *Tour in Wales*, and *The Beauties of England and Wales*, vol. xvii. p. 349.

MACLAURIN, Colin, a celebrated Scotch mathematician, was descended of an ancient family that possessed the island of Tiree, on the coast of Argyll, and was born at Kilmoddan, in February, 1698. His father, who was minister of Glendaruel, having died six weeks after the birth of his son Colin, the charge of him devolved principally upon his uncle Daniel, who was minister of Kilfinnan; and, upon the death of his mother in 1707, he was placed entirely under his uncle's care. In the year 1709, when only 11 years of age, he went to the University of Glasgow; and about a year afterwards, having accidentally met with a copy of Euclid's *Elements*, he exhibited his singular turn for mathematics by making himself master of the six books without any assistance. In 1713, he took his degree of master of arts with much applause, and, on this occasion, he defended publicly a thesis on the power of gravity.

Having resolved to enter the church, he began the study of divinity; but after having spent a year in it, he quitted the university, and lived in retirement with his uncle till the autumn of 1717, when, in consequence of a vacancy in the mathematical chair of Marischal College, Aberdeen, he became a candidate for that situation, and had the good fortune to obtain it. In the year 1708, he communicated to the Royal Society a paper *On the construction and measure of curves, by which many infinite series of curves are either measured or reduced to simpler curves*, which was published in their transactions for that year; and, in the vacation of 1719, he paid a visit to London, where he was introduced to Dr. Hoadley, Dr. Clarke, and the immortal Newton, whose friendship he always reckoned the greatest honour and happiness of his life. On this occasion, he laid before the Royal Society another paper, entitled *a New Universal Method of describing all kinds of Curves by means of Right Lines and Angles only*, and he had the honour of being admitted a fellow of that learned body. In 1720, he published, with the approbation of Newton, his work, entitled *Geometrica Organica, sive descriptio linearum Curvarum Universalis*, in which he examined the various methods proposed by mathematicians for describing geometric curves, and demonstrates a new method of a more general nature. In a second visit, which he paid to London in 1721, he became acquainted with Martin Folkes, Esq. who afterwards succeeded Newton as president of the Royal Society, and began a correspondence with him, in which he communicated to him all his views and improvements in the sciences. In 1722, Maclaurin went abroad with the eldest son of Lord Polwarth, the British plenipotentiary at the congress of Cambray. After visiting Paris and other parts of France, they settled in Lorraine, where Maclaurin wrote his *Memoir on the percussion of Bodies*, which gained the prize of the Royal Academy of Sciences for 1724. In consequence of the death of his pupil, soon after they quitted Lorraine, our author returned to Aberdeen; and a short time afterwards, by the recommendation and interest of Sir Isaac Newton, he was chosen assistant to Mr. James Gregory, who was then professor of mathematics in Edinburgh. In November, 1725, he was introduced to his new situation in Edinburgh; and such was his popularity as a teacher, that he often had more than 100 pupils. In 1726, he published, in the *Philosophical Transactions*, a paper "*concerning Equations with Impossible Roots*," in which he demonstrates, by the common algebra, Sir Isaac Newton's rule for discovering when an equation has impossible roots.

The publication of Dr. Berkeley's *Analyst* in 1731, in which he endeavours to overturn the doctrine of fluxions, induced Mr. Maclaurin to draw up his *Treatise on Fluxions*, which was published at Edinburgh in 1742, in 2 vols. quarto, and was then the most complete work on the subject.

In 1740, Maclaurin shared with Daniel Bernoulli and Euler the prize offered by the Royal Academy of Sciences for the best solution of the problem of the tides. It is said that he had only ten days to draw up this paper, and that he was not able to get it transcribed.

When, in the year 1739, the Earl of Morton went to visit his estates in Orkney and Shetland, he requested Mr. Maclaurin to assist him in settling the geography of these islands, in surveying their coasts, and in examining their natural history. His domestic affairs, however, compelled him to decline the request; but he drew up a memorial on the subject, and furnished the requisite instruments, recommending the celebrated optician Mr. Short as a fit person to use them.

The scheme of opening a passage to the South Sea, across the pole, was always a favourite one of our author's,—and he often said, that if his situation would permit him, he would willingly undertake such a voyage at his own expence. In 1741, when plans for this purpose were laid before Parliament, he was consulted by several persons of high rank upon the subject; but before he could finish his memorial, the premium offered by government was limited to the discovery of a north-west passage, a limitation which he used to regret, as he was persuaded that if such a passage were to be found, it could not be far from the pole.

During the rebellion in 1745, Maclaurin took an active part in favour of government, and assisted in fortifying the city of Edinburgh against the rebel army. Upon the surrender of the city to the rebels he fled to England; and having arrived in the neighbourhood of York, he was invited by Archbishop Herring to reside with him during his stay in the country. The hardships to which our author was exposed in this journey, and which he had suffered before his escape from Edinburgh, are supposed to have brought on the illness which terminated his valuable life. On his return to Edinburgh, his disease was found to be dropsy: and though he was thrice tapped, he experienced little relief, and was carried off on the 14th June, 1746. His remains were interred in the Grey Friars church yard, on the south side of the new Grey Friars church, on the wall of which is placed a tablet to his memory.

In the year 1733, Mr. Maclaurin married the daughter of Mr. Stewart, Solicitor-General for Scotland, by whom he had four children, all of whom survived him. One of his sons was raised to the Bench, under the title of Lord Dreghorn, in 1787.

Beside the works we have mentioned, Maclaurin wrote in the Philosophical Transactions, *on the Roots of Equations, with the demonstration of other rules in Algebra*, 1729, vol. 34, p. 59. *On the Description of Curve Lines*, 1735, vol. 39, p. 143 and p. 148. *Observations on the Eclipse of February* 18*th*, 1737, *Phil. Trans.* 1738, vol. 40, p. 177. *A Rule for finding the Meridional parts to any Spheroid, with the same exactness as in a Sphere*, 1741, vol. xli. p. 808. An account *of his own Treatise on Fluxions*, 1742-3, vol. xlii. p. 325, 403. *Of the Bases of the Cells where the Bees deposit their Honey*, 1743, vol. xlii. p. 565. Mr. Maclaurin left behind him *A Treatise on Algebra*, and *An Account of Sir Isaac Newton's Philosophical Discoveries*, both of which were published after his death. The last of these was undertaken at the request of Mr. Conduit, Sir Isaac's nephew.

There are few men who have united, in such a high degree as Mr. Maclaurin, the reputation of great talents with all the domestic and Christian virtues. Like his friend Sir Isaac Newton, he was sincerely and deeply attached to the Christian religion, and exhibited in his conduct that humility, piety, and benevolence, which evinced the sincerity of his opinions. His ardent love of science led him to patronise every ingenious invention, by whomsoever it was brought forward; and, free from that jealousy and envy of other men's labours, which are the never-failing indications of vulgar genius, he encouraged every species of ingenuity, but especially that kind of uneducated talent which so often appears in a country like ours. His constant kindness and attention to that self-taught genius, James Ferguson, has been recorded by this author in his own life; and it appears that he even requested him to read a lecture upon his Orrery to the students of one of his mathematical classes.

MACLE. See Mineralogy.

MACON, anciently Matisco, a town of France, and capital of the department of the Saone and Loire. The town has a mean appearance, and there is scarcely one good house in it. The cathedral was destroyed during the Revolution. It has no manufactures, excepting one of stained paper. The quay upon the Saone, which is planted with good houses, is very agreeable. There is an island in the river, a little above the bridge, which consists of 13 arches. The confectionaries of Maçon, particularly those called Cotignac, have been long celebrated ;. and its wines are highly esteemed, and form a considerable object of commerce. There is here a society of agriculture and the arts, which has been of great service to the department. The celebrated Abbaye of Cluny, about four leagues north of Maçon, is now in ruins. Population 10,807. East Long. 40° 50′ 8″. North Lat. 46° 18′ 47″.

MACPHERSON, James, a celebrated Scotch poet and historian, was born at the village of Ruthven, in the lordship of Badenoch, and county of Inverness, in the year 1738. He received his early education at the School of Ruthven; and, after having acquired there a competent knowledge of the Latin and Greek languages, he entered King's College, Aberdeen, about the beginning of November, 1752. His talent for poetry displayed itself at this early age, and he employed himself more in the composition of humourous and doggrel rhymes than in the ordinary occupations of a student.

After leaving college he taught the School of Ruthven—an employment which, in that part of the Highlands, commonly falls to the lot of young men who are destined for the church. Here he had sufficient leisure to indulge his taste for poetry. He composed his poem called *Death*, and, in the year 1756, he seems to have written the poem called the *Hunter*, which appears to be only a rude sketch of the *Highlander*, which he afterwards published in 1758. About the same time he published, in the Scots Magazine, a poem on Marshal Keith, and a number of lesser poems, which have been collected by Mr. Laing. The most perfect of these are called the *Cave* and the *Night Piece*; and Mr. Laing agrees with Dr. Blair in the sentiment—that, whatever genius could produce, the first of these poems must be judged fully equal to any performance contained in Mr. Macpherson's Ossian.

The late celebrated Dr. Adam Ferguson having committed to writing, about the year 1740, some fragments of Highland poetry, had frequent conversations with Mr. Home, the author of Douglas, on the existence of ancient poems in the Highlands. In the autumn of 1759, when the Rev. Dr. Carlyle and Mr. Home accidentally met Mr. Macpherson at Moffat, where he was residing with his pupil, the son of Mr. Graham of Balgowan, Mr. Home enquired concerning the remains of Erse poetry, and was told by Macpherson that he had several pieces at that time in his possession. Mr. Home expressed an anxious desire to see these poems; but, being unable to read the Gaelic language, Mr. Macpherson translated for him the fragment on the death of Oscar. In a few days he produced two or three other poems, which Mr. Home carried to Edinburgh. These pieces met with the most extraordinary degree of admiration. Gray and Shenston lavished upon them the highest encomiums; and Dr. Blair, "struck with the high spirit of poetry which breathed in them, procured from Macpherson, by the most urgent importunities, the translations of the remaining fragments. These poems were published in June, 1760, under the title of "*Fragments of Ancient Poetry, collected in the Highlands of Scotland, and translated from the Gaelic or Erse Language*," with a preface by Dr. Blair. A subscription was now set on foot by the Faculty of Advocates, and a considerable sum was raised, which enabled Macpherson to go to the Highlands of Scotland in search of other fragments. With these he returned in the following winter; and, having removed to London by the advice of his friends, he published, in 1762, under the patronage of Lord Bute, *Fingal, an Epic Poem, in Six Books, with other lesser Poems*. In 1763, he published the poem of *Temora*, in eight books, together with several other poems; and Dr. Blair, in his critical dissertation on these poems, has "assigned Ossian a place among those whose works are to last for ages."

Although the belief in the authenticity of these poems was now very general, yet many learned and respectable individuals did not scruple to call in question the general opinion; and the conduct of Mr. Macpherson himself undoubtedly gave no inconsiderable sanction to the hypothesis, that the poems ascribed to Ossian were in a great measure his own composition.

After the publication of Fingal and Temora, which added considerably to Mr. Macpherson's fortune, as well as to his reputation, he was appointed, in 1764, private secretary to Captain Johnstone, who was chosen governor of Pensacola; and our author also received the situation of surveyor-general of the Floridas. Having contributed to the settlement of the civil government of the colony, he visited several of the West India islands, and some of the provinces of North America. He returned to England in 1766, and was allowed to retain for life his salary as surveyor-general, which amounted to 200*l.* per annum.

Having thus acquired a moderate independence, Mr. Macpherson was enabled to pursue his literary labours, more as a source of amusement than of profit. In 1771, he published, in 4to. *An Introduction to the History of Great Britain and Ireland*, &c.

About this time, he was induced, by the advice of his literary friends, to undertake the translation of Homer's Iliad, and if posterity shall think that he failed in the task, it must be ascribed not to any undue estimation which he had formed of his own powers, but to the too great partiality of his friends. "I am exceedingly glad," says that celebrated critic, Dr. Blair, "to learn that you have undertaken Homer. Ferguson's idea, that you was a proper person for such a work, is not new. Ever since your translation of Ossian, we have been often saying the same in this country, and, if I mistake not, I have more than once told you so." With such opinions in favour of his qualifications for the task, it was no wonder that our author persevered in it with some confidence of success. Early in 1773, this work appeared in two volumes 4to; and though it met with a severe reception from some of the English critics, yet his literary friends in Scotland held it in higher estimation. "It is the only translation," says Principal Robertson, in a letter dated April 10th, 1773, "in which Homer appears like an ancient poet in his own simple magnificence. In all those passages where there is much elevation of expression, or great power of description, the translation is very happy, and the force of the original is conveyed in beautiful and flowing language. I am persuaded that, when the first rage and clamour of the English subsides, this will be the judgment universally received."

In the year 1775, Dr. Johnson published his *Tour in the Hebrides*, which contains some severe remarks upon the translation of Ossian. Mr. Macpherson replied to him in a menacing letter; but the scurrility of the moralist surpassed the irritation of the poet, and, excepting an attack upon Johnson, which appeared in Mr. Macnicol's *Answer* to Johnson's Tour, published in 1777, and which has been without reason ascribed to Macpherson, we do not know that this quarrel had any other result.

In 1775, Mr. Macpherson published the *History of Great Britain from the Restoration to the Accession of the House of Hanover*, in two volumes 4to, which, like all others of a political nature, was as highly extolled by the Tories, as it was abused by the Whigs. For the copyright of this work, Mr. Macpherson received from Messrs. Strahan and Cadell the very large sum of 3000*l.* Along with it he published, in two volumes 4to. *Original Papers containing the secret History of Great Britain, from the Restoration to the Accession of the House of Hanover; to which are prefixed, Extracts from the Life of James II. written by himself.* These papers were principally collected by Mr. Carte; but Mr. Macpherson went himself to Paris in 1774, and obtained access to the Stuart Papers, and to other very important documents, which threw great light upon the recent history of the period of which he treats. By the influence of Count Patullo, and others at the court of Versailles, he obtained also important information from the *Depôt des Affaires Etrangeres.*

An attempt has recently been made, by an anonymous writer, under the obvious influence of political rancour, to charge Mr. Macpherson with historical infidelity, in the account which he has given of the Stuart MSS. Had not such a charge been in itself ridiculous, and entirely disproved by the very facts which the author adduces in its support, it would have shared the discredit which Principal Gordon has thrown, by his own personal testimony, upon another statement of the same author. The following anecdote, which we copy from the Supplement to the third edition of the Enciclopædia Britannica, Edin. 1801, and written 15 years before this unwarrantable attack upon Mr. Macpherson's memory, will point out the probable origin of these calumnies:

"The writer of this sketch once saw a gentleman of rank, and of the Whig interest, turn over one of Macpherson's volumes, and heard him say, upon shutting the book, 'I cannot bear that work.' He was asked if he thought the narrative false? and he replied, 'No! *It is too true;* but I cannot bear it, because it gives me a bad opinion of those great men, to whom I have been accustomed to look back with reverence as the saviours of my country.' That it has been abhorred by others on the same account," continues this writer, "we have not a doubt; and yet language has no name too contemptuous for those who will not follow truth, whatsoever she may tell them; or who, on the absurd pretence of their having already made up their minds, will not study the evidence on both sides of a disputed point of our national history."

After the publication of these works, Mr. Macpherson's reputation and fortune increased with much rapidity. Both he and his great opponent, Dr. Johnson, were engaged by the ministry of the day, to defend their public measures; and both of them contributed the aid of their talents to support the unrighteous war which was waged against the liberties of America. Among many other productions, of which we have not room for a detailed list, Mr. Macpherson wrote "*The Rights of Great Britain Asserted against the Claims of the Colonists; being an Answer to the Declaration of the General Congress in* 1776;" a pamphlet which obtained great popularity, and went through several editions. In the year 1779 he published *A Short History of the Opposition during the last Session of Parliament;* a pamphlet which was very generally ascribed to the pen of Gibbon.

About this time Mr. Macpherson obtained the lucrative appointment of agent to the Nabob of Arcot, and he discharged his duties to that unfortunate sovereign with great fidelity and zeal. Among other appeals which he made to the public in behalf of his client, he published "*Letters from Mohammed Ali Chan, Nabob of Arcot, to the Court of Directors; to which is annexed, a State of Facts relative to Tanjore, with an Appendix of Original Papers*, 4to. 1777;" and he was believed to be the author of "*The History and Management of the East India Company, from its Origin in* 1600 *to the present time; also, containing the affairs of the Carnatic, in which the Rights of the Nabob are Explained, and the Injustice of the Company Proved.*" 4to. 1779.

In the year 1780, Mr. Macpherson was elected member of Parliament for the burgh of Camelford, and he was elected to the successive Parliaments of 1784 and 1790.

About the year 1790, he purchased the estate of Raits, and other two properties in the county of Inverness. To the first of these he gave the name of Belleville, and built upon it a large mansion, commanding an extensive and beautiful view of the valley of Badenoch. In consequence of the failure of his health, he retired annually from the bustle of active life, and spent several months in this sequestered spot, occupied, we believe, chiefly in preparing for the press the Poems of Ossian in the original Gaelic. His health, however, continued to decline; and, after lingering for some time, he died at Belleville, on the 17th of February, 1796, in the 58th year of his age. His remains were carried from Scotland, and interred in the Poet's Corner of Westminster Abbey; and a very elegant marble monument was erected to his memory, on a gently wooded eminence upon his own estate, and close to the great military road to Inverness.

Mr. Macpherson left a very ample fortune, which is now possessed by his eldest son. He bequeathed annuities to several persons to a great amount, and among these, one of 1000*l.* to John Mackenzie of Fig-tree Court, London, to defray the expence of printing and publishing the Poems of Ossian in the original Gaelic. They were accordingly published in 1807, under the title of *The Poems of Ossian in the original Gaelic, with a literal Translation into Latin, by Robert Macfarlane; and a Dissertation on the Authenticity of the Poems, by Sir John Sinclair*, 3 vols. 8vo.

Mr. Macpherson has left behind him an immense collection of letters from the principal literary and political characters of the period in which he lived. He had the honour of numbering among his particular friends, the Rev. Principal Robertson, David Hume, Esq. Dr. Adam Ferguson, Mr. John Home, the author of Douglas, Dr. Blair, David Garrick, Dr. Douglas, bishop of Salisbury, and Mr. Whitaker. His friendship with almost all these individuals continued uninterrupted during the whole of his life; and his correspondence with them, which still exists, and which we trust will some day or other be given to the public, is marked with a degree of affection which we have seldom seen in the correspondence of literary men.

Like all those men who have taken an active part in the political transactions of the day, or who have freely expressed their opinions on the party transactions of other times, Mr. Macpherson has not escaped from the current of political malignity, which one faction never fails to direct against another. His attachment to Tory principles, and the unpleasant details which he has brought to light in his historical writings, have exposed his memory to the cowardly attacks of political writers, who would have shrunk before him when alive. In order to give force to their calumnies, they have availed themselves of the mystery which hangs over the Poems of Ossian, to throw discredit upon his political labours. It is thus that the great cause of civil and religious liberty, which every good man loves, is degraded, by becoming the tools of demagogues, who neither love their country, nor the constitution which they are apparently so zealous to preserve.

With respect to the Poems of Ossian, we believe there is now only one opinion among literary men, that Mr. Macpherson was at least as much the author as he was the translator of Ossian; and that no statement could be more correct in the case of these poems, than that which is made in the Preface to the 2d Edition, "that a translator, who cannot equal his original, was incapable of expressing its beauties."

It has of late become common among an inferior class of writers, to depreciate the merit of the Poems of Ossian; but these opinions will have little weight, when contrasted with those which have been entertained by the most eminent critics of the present day.

"The great and continued popularity of Macpherson's Ossian," says the most distinguished critic of the present age,[*] "proves how very fascinating a fabric might be raised upon that foundation by a more powerful or judicious hand. That celebrated translation, though defaced with the most childish and disgusting affectations, still charms with occasional gleams of a tenderness beyond all other tenderness, and a sublimity of a new character of dreariness and elevation, and, though patched with pieces of the most offensive plagiarism, still maintains a tone of originality, which has recommended it in every nation of the civilized world." And, in another place, the same author remarks, that "while we are compelled to renounce the pleasing idea that Fingal lived, and that Ossian sung, our national vanity may be equally flattered, by the fact, that a remote and almost a barbarous corner of Scotland produced, in the 18th century, a bard capable not only of making an enthusiastic impression on every mind susceptible of poetic beauty, but of giving a new tone to poetry throughont all Europe."[†]

The Poems of Ossian have gone through an immense number of editions in Great Britain and America, and have been translated, we believe, into all the languages of Europe.

MADAGASCAR, one of the largest islands in the world, is situated on the south-east coast of Africa, between 12° and 26° south latitude, and between 43½° and 51½° east longitude from Greenwich. It extends about 900 miles in length, and 360 at its greatest breadth. It appears to have been unknown to the ancient geographers, though supposed by some learned writers to have been the Erne of Pliny, and the Menuthias of Ptolemy. It was first mentioned under its present name by Marco Polo, in the thirteenth century, and it is said to have been discovered in 1506 by the Portuguese navigator Lorenzo Almeyd. Its most ancient designation among the oriental writers is Sarandib; while, in the language of the inhabitants, it is always denominated Madecasse, from which is obviously derived the modern name of Madagascar.

The island of Madagascar is divided in a longitudinal direction by a lofty ridge of mountains, which separate the eastern from the western coast, but approach nearest to the former. Many of these mountains are covered to the summit with lofty trees, or with verdant herbage, while others present the most imposing views of precipices, cataracts, and every form of grand and picturesque scenery. The two highest of these mountains are Vigagora in the north, and Botistmene in the south, and are not less than 1800 fathoms above the level of the sea. The island, though diversified in its whole extent by hills, lakes, and marshy tracts, contains many beautiful vallies, extensive plains, comprising, as has been estimated, not less than two hundred millions of acres of excellent land, remarkable for fertility of soil, and covered with the greatest variety of valuable productions.

There are numerous streams and rivers flowing in all directions from the mountainous ridges in the middle of the island; and serving at once to fertilize and beautify the districts through which they pass. Some of these rivers are of considerable magnitude, and even navigable by large vessels for several leagues. The largest and best known are, the Fanshere, which has its source at the foot of the Manghabey mountains, and falls into the sea about two leagues from fort Dauphin, supplying water to the lake of Amboule, which is 10,000 fathoms in circumference, and the mean depth of which is about 40 feet; the Manghasia, which enters the sea near the island of St. Claire, in 24° 31′ south latitude; the Mandrarey, a very rapid stream, which runs southward, and falls into the sea about 50 miles south of fort Dauphin; the Manatingha, which flows north-east through Amboula, and discharges itself into the sea under the tropic of Capricorn; the Mananghera, a large river south of the province of Matane, originates far inland, and empties itself into the sea by seven mouths; the Ongleby, south of Foul Point, a beautiful river, which disappears in the sand about four miles above its mouth, but is navigable for boats about 20 leagues inland; the Linguebate, at Louisburgh, in the bay of Antongil, is navigable by boats seven leagues from its mouth, and at that distance is 150 fathoms in breadth; the Yonghelake, which flows into the bay of St. Augustin, after a course of more than 70 leagues.

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[*] Edinburgh Review, Vol. XVI. p. 280.

[†] Id. Vol. VI. p. 462.

The topography of this noble island is remarkably deficient. The whole of the interior, and the greater part of the western coast, may be considered as altogether unknown; and even respecting the most frequented portions of the eastern division, the information hitherto procured is extremely superficial. Its provinces, however, have been enumerated to the number of twenty-eight; but little dependence can be placed upon the accuracy of the distribution, or even of the names.

The province of Anossi, or Carcanossi, lying in 25° south latitude, is bordered on the coast with rocks, shoals, sand, and jungle; but its inland tracts abound in hills covered with wood, fruitful plains, and fine pastures. The principal tribe of its inhabitants are called Zafferahimini. Mandrarey, to the south-west of the last mentioned, is generally of a barren soil, producing chiefly cotton and palm-oil. Manapani, or Manatingha, north of Anossi, includes the fertile and populous valley of Amboule. Manamboule, or Mamboule, is an inland hilly tract, in 22½° south latitude, surrounded by mountains, abounding in iron ore. Alskach, or the vine country, west of Mamboule, and in the interior of the island, is fruitful in vines. Anachimoussi, a mountainous province in 21° 40′ south latitude, is covered with forests, and is hitherto unexplored. Matatane, in 21½° south latitude, produces rice, sugar cane, honey, &c. but the number of streams in the country renders the air moist and insalubrious to strangers. Erindranou, westward of the last mentioned, in the interior of the island, consists of mountains covered with wood, and containing iron ore, and of populous vallies yielding rice and fruits. Antevares, stretching along the coast from the north border of Matatane, is a low and marshy district, in the northern part of which is a lake 15 miles in length, and nearly the same in breadth, which has a communication with the sea. Ambohitsmene, west of the preceding, an elevated and woody tract, receives its name from a chain of red mountains, which extend to the north extremity of the island. Guallembolou, or Voulou-Voulou, a maritime province north of Antevares, from which it is separated by the river Tametavi, is a beautiful well watered country. Manghab, north of the last mentioned, is full of bays, the largest of which, named Antonio Gillo, or Antongils, is about fourteen leagues in length, and nine in breadth, having the island of St. Mary at its entrance, and that of Marrotte near its other extremity. Andouvouche, an unexplored province covered with forests, separated from Manghab by the red mountains, extends westward to the sea-coast, where it contains three spacious bays, between 13° and 15° south latitude. Vohemaro, or Boamaro, so named from a port on the east coast frequented by the Portuguese, is the most northern province of the island, and abounds in rice and fruits. Lamanon, Mazelage, St. Andrew, Antrianach, Hazon-ringhets, Conchaa, Lahafonte, are the names of territories between the red mountains and the west coast, which have never been visited by Europeans, and the shores of which are bounded by an extended sand bank. Tvouron-behoe, a barren maritime province on the west coast, in 23° south latitude. Houlouve, south of the tropic, the mountains of which are said to contain amethysts and rock crystals. Sieuh, or Sivah, a dry and barren tract, bordering on the last mentioned. Country of the Mahafales, a race of shepherds, who occupy the south-west corner of the island, is watered by numerous streams, and full of pasturage. Maehicore, an inland district of great extent, and almost equi-distant from the east and south coasts, the inhabitants of which dwell in forests full of wild cattle. Caremboule, a maritime tract on the south coast, abounding in cotton, pulse, and pastures. The territories of the Ampatres, east from the preceding, is partly fertile, and partly covered with jungle. The most southerly point of the island is Cape Romain in this province, and the most northerly is Cape Sebastian in Vohemaro. The places most frequented by Europeans, and most throroughly known, are Fort Dauphin in the south, and Foul Point in the north of the island. Fort Dauphin is built on the peninsula of Tholanga, in 25° 3′ south latitude, and 47° 24′ east longitude from Greenwich, about two leagues north of the river Fanshere. It is of an oblong figure, surrounded with good walls, built with lime and sand, and covered with strong cement; and stands 150 feet above the level of the sea. It is not enclosed on the side towards the sea; but the shore is bold, and surrounded with breakers, so that a landing is at all times difficult, and a few additional works would render access impracticable. The peninsula increases in breadth very gradually, and might be secured from any attack of the islanders by redoubts and pallisades. The anchoring ground is excellent, but the entrance of the harbour is difficult; and the strong north-east winds are very troublesome to the vessels moored in the port. The lake of Amboule would form an excellent harbour, were the sand banks, which obstruct the entrance cleared away; which is considered as by no means an impracticable work. There are certain times, when a sudden swell of the tide has diminished the bar of sand so much, that large vessels might easily be carried into this capacious basin. The river of Fanshere, which runs into the sea two leagues from Fort Dauphin, near to Cape Ravenate, on the south of the harbour, might, with a little labour, be rendered navigable for boats to a distance of nearly 20 leagues from its mouth. The country around Fort Dauphin, especially the valley of Amboule to the north, is highly fertile and populous, and capable of affording an abundant supply of provisions.

Foul Point, called by the natives Voulou-Voulou, situated in 17° 40′ 20″ south latitude, and 49° 50′ east longitude, is one of the best ports in the island. It is surrounded by a reef of coral rocks, which break the force of the waves; and the least depth of the water is 23 feet at low tides. The shores on all sides are very bold, and ten large vessels may be moored alongside each other in sure anchorage, and sufficient depth of water. The entrance, which is on the north side, is about 50 fathoms in breadth; but, in the winter season, is obstructed by a shifting sand bank, which is occasioned by the north breezes, but is again dissipated by calm weather or south-east winds. The highest rise of the spring tides, or fall of the neap tides, is between four or five feet. At the lowest tides, the reef of rocks appear above water; and present a variety of curious natural productions, such as mosses, marine plants, black coral, madrepores, sea-stars, insects, and shells of numberless forms and brilliant colours. The mouths of the river on this coast are bordered with mangles, which are loaded with excellent oysters, adhering to the branches in clusters of the most singular figures. At a little distance above water-mark, are found veins of sand different from that of the shore; and which, from being mixed with soft friable stones and small glassy fragments, appear to have experienced a partial vitrification.

The coast of Madagascar is in many places covered with jungle and marshy grounds; but the country inland presents a rich and beautiful appearance. The most picturesque scenes and rural views open to the eye at every step. Extensive meadows at the bottom of the vallies, watered by numerous winding streams, afford the richest pasture to the sheep and cattle with which they are crowded; while tufts of trees, scattered irregularly over their surface, and brilliant flowers of every hue among the herbage, give them the appearance of parks or pleasure grounds, ornamented by the hand of art. Upon approaching the mountains, the scenery becomes still more interesting, from the multitude of little hills, of every varying form, which shelter the vallies and multiply the landscapes. In the mountainous districts, the changes of prospect are sudden and picturesque beyond any thing that can be conceived, so as completely to bewilder the imagination among the multiplicity of interesting objects.

In many parts of the coast, the noxious vapours arising from the woods, marshes, and great quantities of sea-weed driven ashore by the currents, render the climate extremely unhealthy; and from the month of October to May, intermittent and pestilential fevers are found to prevail. Even the natives find it necessary, during that season of the year, to seclude themselves in their huts in the midst of a thick smoke; nor can the most robust and temperate among them wholly withstand the malignancy of the disease. The best security to Europeans, is to keep themselves on board their ships as much as possible, surrounded by the sea air, and to observe every precaution in their intercourse with the islanders. It is chiefly during the prevalence of the north wind that this pestilential state of the atmosphere is most virulent; hence it varies greatly in its ravages, in different years; but rarely is any part of the north-east coast altogether free from putrid fevers in the winter months. The southern coast, as being farther removed from the equator, is more healthy than the northern; and the interior of the island is more salubrious than any part of the coast. The thermometer of Reaumur was never observed to rise in the neighbourhood of Foul Point above 27°, or to fall below 15°; and the heat is much less oppressive in the more elevated country towards the interior. The barometer exhibited in the same place very little variation, being always between 28 inches 2 lines, and 28 inches 5 lines.

The mineralogical productions of Madagascar are still very imperfectly known; but the anticipated wealth of its mines was one of the principal objects of the French establishments on the island. Iron mines of an excellent quality, and very near the surface, are found in every part of the country, from which the natives easily procure a soft and malleable metal, equal to any in the world. Enormous blocks of rock crystal are found in the mountains of Ambotismene; and indices of tin mines are sufficiently obvious in many places. Gold ore, topazes, sapphires, emeralds, and spotted jaspers, have been particularly distinguished.

But the innumerable vegetable productions of this island form its principal riches, and indicate the extraordinary fertility of its soil. They are chiefly known, however, by the native names, and cannot be easily classed or described. The forests contain a prodigious variety of beautiful and useful trees, calculated either for the purposes of the carpenter or the cabinet-maker. Some of the more remarkable and valuable kinds are, Vouaazigné, the straightest and tallest tree in the island, the wood of which, yellow, hard, and heavy, is used for building houses, or more commonly for keels to the piroguas; and the oil of which, clear and palatable, is mixed with rice in the usual mode of preparing it for food; Harame, a very large tree, with a smooth trunk, which, after attaining its full size, casts its outer bark every year, and yields, by incision, a resinous aromatic gum, which is burned as a perfume, or used as a paste by the women, for preserving the freshness of the skin; Fouraka, lofty and bushy, next to the teak for the purpose of ship-building, and yielding a green-coloured balsam, which is greatly esteemed as an application to wounds; Tevartna, remarkably beautiful in shape and foliage, having a smooth straight trunk, surrounded with bushy branches, placed horizontally in such a manner as to give it the appearance of a pyramid consisting of seven stories; Finguere, a kind of wild fig-tree, yielding a milky juice, which coagulates into an elastic gum, like that of the caoutchouc, and of which the natives make excellent flambeaux for various purposes, but particularly for fishing during the night; Raven, a species of palm-tree peculiar to the island, and one of the most useful to the inhabitants, who procure large planks from its fibrous wood for constructing their houses,—make the partition-walls from the ribs of its leaves, which have the solidity of wood and the pliability of leather,—employ the leaves as a durable thatch for the roofs of their dwellings, or as a ready material for making plates and other dishes, which they never use more than once,—prepare its top-part, which is a kind of cabbage, as an article of food,—and draw from the membraneous covering of its flowers a gummy substance of an exquisite taste resembling honey. Besides these, there are palms of every kind, bamboos of enormous size, and ebony,—a wonderful variety of dye-woods, aromatics, and medicinal plants. There are, particularly, the ancient papyrus, the cotton tree, the indigo plant, flax and hemp, nutmeg trees, the common and betel pepper, tobacco, ginger, turmeric, and cinnamon. The principal fruit trees are, cocoa nuts, Indian figs, pine apples, pomegranates, tamarinds, oranges, lemons, and wild vines. There is an endless variety of flowering shrubs and curious plants; which would occupy, says

Rochon, " the most indefatigable botanist, in the course of a long life, to make himself even slightly acquainted with their natural history." The more common esculent plants are, sugar cane, bananas, yams, nymphda lotos, gourds, water-melons, turnips, pulse of various kinds, particularly the dolichos or kidney bean. The yams are remarkably numerous, some of them as large as the thigh of a grown person, and all of them fit for supplying food to man or cattle. There are also many roots growing wild, and one, particularly, called by the natives fanghits, which grows to the size of a man's body, is said at once to allay thirst and satisfy hunger, to be pleasant to the taste, and easy of digestion. Among the peas is one called varoattes, resembling the caper shrub, which grows to the height of the cherry tree, and produces in each pod a pea about the size of a lentile. The barley of Madagascar is a beautiful grain; and the island produces six distinct kinds of rice. The soil requires little cultivation, and is only slightly turned with a hoe. The rice, merely dropped into small holes in the ground, and covered by means of the foot pressing down the mould, will yield a hundred fold. Among the most abundant productions of the island, which might be rendered important objects of commerce, are, wax, honey, and silk. There are no elephants, lions, tigers, or horses, among the quadrupeds of Madagascar; but great numbers of buffaloes, wild-boars, porcupines, dogs, monkies, cameleons, civet-cats, squirrels, rats, and mice; and the more domestic animals, horned cattle, goats, hogs, and sheep, are reared in the greatest abundance. One species of the sheep have large flat tails, weighing twenty or twenty-five pounds; and the wool in general, though little used by the natives, is extremely beautiful. Of the feathered tribes there are, eagles, crested storks, pelicans, herons, guinea-fowl, teal, wild-turkeys, pheasants, pigeons, partridges, paroquets, finches; a bird called samba, with plumage as red as fire; a white bird, which follows the cattle, and feeds upon the flies and beetles that infest their skins; a bat of monstrous size and hideous appearance, yet more delicate and palatable as food than the best poultry. Among the fish which frequent the coasts and rivers are, the dorado, breams, soles, pilchards, herrings, mackarel, oysters, muscles, crabs, and turtle, fine eels, and fresh-water mullets. Some kinds of fish found on the shores of Madagascar are of a poisonous quality, which is ascertained by a piece of silver becoming black when placed under their tongue. In the large rivers are crocodiles of a monstrous size, which have often been seen to drag away and devour a full-grown ox, and which are very apt to surprise the unwary traveller. Serpents are not uncommon in the island, but none of them large or poisonous. Among the insects are beautifully variegated butterflies, beetles which shine in the dark, and silk-worms with four feet. Several of the insect tribes are sufficiently troublesome, and some of them (especially a large spider, and a broad-shaped caterpillar,) inflict very painful bites; but a water-scorpion is said to be the only venemous creature in the island that inflicts a mortal wound.

The natives of Madagascar are a mixed race, and divided into a great number of tribes. Many of them are obviously sprung from the African negroes; but others have all the characteristics of an European or Asiatic origin; and it appears highly probable that some parts of the island have been occupied by those Arab tribes who are known to have penetrated very far into the continent of Africa. It is at least unquestionable, that they have introduced their language, and left numerous traces of their religious system, among the Madagasses. The whites, including all who are not descended from the negro race, ascribe their origin to different sources. Those who inhabit the province of Anossi pretend to be sprung from Tmina, the mother of Mahomet, and have assumed the name of Zafferahimini. Those who occupy Foul Point, St. Mary's Island, and the Bay of Antongil, are descended from the pirates and the Jews; and call themselves Zaffe-Hibrahim, descendants of Abraham. A third class, who profess to teach the Arabic language, represent their ancestors as having been sent to Madagascar by the Caliph of Mecca, to instruct the inhabitants in the secrets of nature, and the religion of Mahomet. These intruders, who are called Zaffi-Casimambou, seized upon the province of Matatane, from which they had expelled the Zafferahimini, its former possessors. These last mentioned people, who believe that they came originally from the sandy plains of Mecca, and on this account are called Ontampassemaca, appear to have at some remote period made a conquest of the island, and exhibit many traces of the Hindoo theology. They are divided into three classes, namely, the Rhoandrians, the nobility of the country, from whom the sovereigns are chosen, and who alone possess the privilege of killing animals for food; the Anacandrians, who are descended from the former and a woman of inferior cast, share in some of the privileges of the nobles; and the Ontzatsi, who have no particular marks of distinction, but are generally soldiers, who study to throw the assagay, and spend their time in sleeping, dancing, and otherwise amusing themselves. The blacks, who are most probably the original natives, are also divided into casts or classes, namely, the Voadziri, who are regarded as the descendants of the ancient sovereigns of the island, and are allowed to possess several villages, are greatly esteemed by their countrymen—and, when not in the presence of their Arab conquerors, exercise the office of killing animals for their subjects; the Lohavohits, a less powerful class than the former, who may possess one village, but, however wealthy in flocks and herds, must never presume to act as their own butchers; the Ontzoa, nearly related to the last mentioned, but without any kind of authority or privilege; and the Ondeves, who are slaves by extraction, and whose name signifies " lost men." The Rhoandrians, or royal tribe, are now reduced to a small number, and exercise a very limited authority. Their subjects are at liberty to change their chiefs at pleasure, and to attach themselves to any one whom they think most capable of securing them protection. They are supposed to be the proprietors of all the land, which they distribute among their people to be cultivated, and for which they require a small quit-rent, called, in the language of the country, "*faensa.*" These chiefs are always armed with a musket, and carry a stick headed with iron, to the other extremity of which is affixed a small bunch of cow's hair. Their heads are covered with a red woollen cap; and it is chiefly by this part of dress that they are distinguished from their subjects. They make war or peace with the concurrence of their people, who are assembled for consultations; and in these meetings, called Palabras, speeches are often made which display considerable energy and eloquence.

A remarkable race of Dwarfs, called Kinios, are said to inhabit the interior parts of the island; and though their existence is regarded by Flacourt as entirely fabulous, it is as decidedly affirmed, both by Bougainville and the Count de Modaue, as sufficiently confirmed by the most credible testimony. The latter, indeed, expressly describes a female Kimos, whom he purchased as a slave. She was about 30 years of age, and three feet seven inches in height. Her complexion was the fairest that had been observed among the natives, and her features approached nearer to those of an European than of the other people of Madagascar. She was well limbed, and tolerably proportioned, except that her arms were very long, and her hands similar to the paws of an ape. Her bosom, also, was as flat as that of the leanest man, without any appearance of breasts. The question, however, to be established, is the existence of a nation of these pigmies, governed by their own laws and usages. According to the information given to Modaue on the subject, and which he considered as perfectly authentic, these people occupy an extensive valley in the interior, surrounded by high and steep mountains, and situated about sixty leagues to the north-west of Fort Dauphin, eastward from the country of the Matatanes. Their chief possesses more absolute authority than any of the other chiefs in the different districts of the island. They avoid all kind of intercourse with the surrounding tribes, and, though unacquainted with fire arms, have been able to repel the hostile incursions of their neighbours. They are said, at the same time, to be so desirous of peace, as frequently to place on their frontiers herds of cattle, to satisfy the rapacity of their invaders, who have generally paid dearly for their temerity, when attempting to penetrate farther into the country. The villages are situated on small steep mounts, and so well defended by various obstructions, as to be almost inaccessible to an enemy. They are reported to be an industrious people, and much occupied in cultivating the soil. The ordinary height of the men is said to be three feet five inches; their form thick and squat; their skin of a lighter colour than that of the other islanders; their hair short and woolly; and their beards long. Their existence, however, is still a subject of doubt among the best informed persons at the Mauritius.

The natives of Madagascar, in general, bear no resemblance to this diminutive race. They are rather above the middle size, and portly in their appearance. The colour of their skin is different in different tribes; among some a deep black, among others a tawny colour, among others a copper tint, but among the great majority an olive hue prevails. All who are black have woolly hair, and other marks of the negro race; but those who have the Indian or mulatto complexion have lank hair like Europeans, a broad open forehead, a nose sufficiently elevated, their lips and features regular and agreeable, and a countenance peculiarly expressive of frankness and good nature. Very various accounts, however, have been given of their character towards strangers, and the degree of confidence to be placed in their amicable dispositions. By Flacourt they are described as the most deceitful, fawning, ungrateful, and revengeful people in the world; while Rochon invests them with all the savage virtues which the imagination of Rousseau has ascribed to uncivilized man. The inhabitants around the Bay of Antongil and the Port of Foul Point are described as more mild in their dispositions, and faithful in their engagements, than those who occupy the other tracts on the east coast towards the south point of the island. Their general suspicion of Europeans, and their readiness to anticipate visitors in what they apprehend to be secretly devised against themselves and countrymen, are, doubtless, too much justified by the villanous arts which have been repeatedly practised against them. But, at the same time, their acknowledged cruelties in the wars which they wage against each other, and the undoubted massacres which they have frequently made of the colonists on their coasts, clearly mark their character with a high degree of ferocity and revenge. At the same time, when they are not excited by the appearance or the apprehension of hostility, they are friendly and hospitable to strangers; and of this disposition several recent shipwrecks on their coast have afforded satisfactory evidence. Mr. Oucruydt, president of the Burgher Senate at Cape-Town, when he was supercargo of a Dutch East Indiaman, found at Augustine Bay the crew of a French ship, who had resided 12 months among the natives in perfect safety, and been treated with the utmost hospitality.

The population of Madagascar was estimated nearly 40 years ago at 4,000,000 by Rochon, and at 3,000,000 by Rondoux; and some of their towns are supposed to contain 25,000 inhabitants.

The towns and villages are commonly situated on eminences, and surrounded by two rows of strong pallisades, within which there is a parapet of earth four feet in height; and some are fortified still further by a ditch ten feet in breadth, and six in depth. The habitation of the chief is called Donac, and contains two or three buildings, surrounded by a peculiar kind of enclosure. It is guarded by slaves night and day, and frequently hung round with bullocks' horns by way of ornament. Their houses are small, constructed simply with wood, and covered with plantain leaves. The floor is raised a little above the level of the ground, as a security against moisture and vermin during the rainy months, and in general kept very clean. They are without chimneys, and are continually filled with smoke, as the fires are kept up for cooking, even in the hottest weather. Their furniture consists of red and yellow rush-mats, neatly and strongly woven, which serve them as seats and beds; baskets, beautifully made by the women from the filaments of the raven leaf, to hold their clothes and ornaments; earthen pots, which they manufacture with great ingenuity; dried gourds for containing water; a few vessels for honey-wine; and leaves of the raven tree for plates, dishes, and spoons, which are renewed at every repast. Their diet is very simple, consisting principally of milk, rice, fish, fruits, and roots. They are scarcely acquainted with the use of salt, but frequently put a little sea-water into their broths; and, in the interior, employ for the same purpose the leaves of a tree called the salt-tree. Their drink is water, or a kind of wine made from the sugar-cane. In respect of dress, a considerable diversity prevails among the different tribes and districts. The negro race are almost completely naked, except that the men wear a piece of linen round the middle—sometimes short drawers; while the women have a kind of apron, and sometimes a long loose robe without sleeves. Most of the white inhabitants are without any covering to the head or feet, except those of Manghabey, where the men wear a square cap, and the women a kind of hood pointed at the top, and hanging down upon their shoulders. Their other parts of dress are of various materials and colours—some of red silk, some of striped cotton, with silk borders, and some of a strong stuff resembling linen, made of the bark of trees, which goes through the several processes of beating, boiling, washing, twisting, or spinning, and weaving. Some kinds of this manufacture are very soft and light, almost equal in beauty to silken stuffs. Of the stronger kinds of this cloth they sometimes make a wide garment, resembling a corn sack, with two holes in the bottom, through which they pass their feet. Their ornaments are different kinds of chains, ear-rings, necklaces, and bracelets, made of pearls, corals, rock-crystals, cornelians, and beads of gold.

A plurality of wives is common among the chiefs and rich men; but one of the number only is considered as the legal spouse, and the rest as concubines. They are not remarkable for conjugal fidelity; and the crime of adultery, when detected, is punished only as a species of robbery. The conduct of the unmarried females is abundantly licentious; or rather the daughters of a family are considered as honoured by having children to strangers; and few marriages take place where the parties have not previously cohabited. In fact, to be taken home to the house of the man, and to live there as long as they are mutually pleased, is all the marriage usually celebrated. Young women, or rather those who have never been thus taken home, are known by having their hair carelessly flowing on their shoulders; while the married females wear it in separate tresses, bound up in the form of a nosegay on the top of the head. The women of Madagascar are described as possessed of considerable personal attractions, and are treated with a degree of respect very unusual among savage tribes, and scarcely equalled among many civilized nations. The balance of power is said rather to incline in their favour; and their presence has the most striking and instantaneous effect upon the spirits of their husbands. They are lively, cheerful, and good-humoured; and the men are never observed to be sad or dejected in their company.

The women are only employed in spinning flax, or making threads from the bark of trees; and are never subjected to the drudgery of field labours. The men are employed principally in agriculture, which requires, in their fertile soil, a very small portion of their labour and attention. Some of them work well in iron, and a few make ornaments of gold. Those on the coast are industrious and enterprising fishermen, who go to a considerable distance from shore in their large canoes; and the inhabitants of the interior are not less successful in their lakes and rivers. They catch a number of birds in a variety of ingenious and dexterous ways; but are not much addicted to hunting, which the chiefs regard as an employment unbecoming their dignity, and which is occasionally followed only by a few of the poorer negroes, who must preserve their plantations of yams on the mountain sides from the depredations of wild animals. The Madagasses are an idle race. They are not, however, deficient in intellect; and about 20 of them, who were under the tuition of Mr. Bartlet, a missionary at the Cape of Good Hope, learned to read English, and repeat the catechism with tolerable facility. They exercise little foresight, and spend the greater part of their lives in sleep and amusement. Their principal amusements are dancing and singing, with a few very simple musical accompaniments. Their songs are, in general, either satires or panegyrics, the former reprehending the follies of the present age, and the latter extolling the deeds of their ancestors. It is particularly the practice of the women to sing and dance almost incessantly while their husbands are engaged in war, as contributing, in their opinion, to animate the strength and courage of the combatants.

Their wars are rarely of long continuance, and are commonly little more than marauding excursions, almost always planned, if possible, so as to take their enemy by surprise, and conducted in the most savage and sanguinary manner. They massacre without mercy all whom they meet in the first assault upon a hostile village, without regard to age or sex, and make slaves of all who survive the fury of the onset. Many of the tribes on the coast are supplied with fire-arms; but the principal weapons of these islanders are shields, lances, and missile darts.

The inhabitants of Madagascar carry on little commerce among themselves, except in the way of bartering the produce of one province for that of another. Neither do they discover any anxiety to find articles of trade for attracting strangers to their coasts; or avail themselves, as they might do, of the demands which they have already experienced for many of their productions. Timber, pitch, tar, whale-oil, salt-fish, manufactured hemp and flax, cotton, and several kinds of silk, indigo, tobacco, honey and wax, sugar, spices, and gums, might be furnished in sufficient abundance for the support of an extensive and regular commerce. A regular traffic, chiefly from the southern part of the island, is carried on with the isles of Bourbon and Mauritius, both in French and English ships. The principal articles brought down from the interior of Madagascar, for this purpose, are cattle, rice, slaves, and cloth; and the commodities which they are desirous of receiving in exchange are powder, ball, fire-arms, knives, European cloths, pictures, and various ornaments. In the more central parts of the island coin is wholly unknown, and all trade consists in barter; but, on the coast, Spanish dollars, which, for farther convenience, are frequently cut into four parts, form a medium of exchange.

Besides their manufactures of earthen-ware, iron-ware, and stuffs for clothing already mentioned, they make in some places both ink and paper of tolerably good quality. The former is prepared from a decoction of the bark of a certain tree called Arandrato; and, though not so black as that of Europe, is naturally of a more shining appearance. The latter is manufactured from the ancient papyrus, named by these islanders Sanga-sanga. They dexterously pull off the inner bark of this, and divide it into thin filaments, which are laid across each other in various directions, and well pressed. They are then boiled in a strong ley of ashes, and pounded in a wooden mortar till reduced to a paste, which is drenched with water on a frame made of bamboo, in the form of a grate, and then spread out to dry in the sun. The paper is of a yellowish colour, and is glazed with a decoction of rice-water. Their pens are made of the bamboo.

They are not altogether unacquainted with the art of writing, and are said to possess some historical books in the native language. But their learned men, who are called Ombiasses, use only the Arabic character; and the Arabic language is said to have made some progress in the north-west part of the island. Some natives on the coast speak a little French and English. But though they have no written character peculiar to their language, it has been so far reduced to a systematic form, that a vocabulary and a catechism have been drawn up in it, which Mr. Milne, now acting as missionary in Malacca, lately procured in the isle of France. These ombiasses, who are their physicians, sorcerers, and oracles, are said to possess treatises on medicine, geometry, and astrology; and the most celebrated generally come from the province of Matatane, where the magical art is practised to a great extent, and whose inhabitants are on that account regarded with dread by the other natives of the island. The ombiasses, whatever description or degree of knowledge they may possess, seem to employ it entirely as an engine for holding the minds of the more ignorant tribes in a state of the most degrading and afflicting superstition. They do not merely exercise their incantations, and dispose of their amulets, from the usual motives of avarice and ambition; but inculcate often, without any apparent profit to themselves, the most inhuman decisions upon the ignorant creatures who are enslaved by their influence. The most execrable of all their practices is the system which they have introduced and upheld, of exposing the children who are born on certain days to be devoured by wild beasts, or to perish by the more lingering effects of cold and hunger. They pretend to discover, by observing the aspect of the planets, all the lucky and unlucky days of birth; and all who happen to come into the world at any of these ill-omened moments are required to be instantly devoted to death. The months of March and April, the last week of every month, or all the Wednesdays and Fridays of every week, are fatal days; so that, nearly for one-half of the year, the population of Madagascar is exposed to an effectual check. To this unnatural practice it is supposed to be principally owing, that the number of the inhabitants bears so inadequate a proportion to the extent and fertility of the island. But the power of natural affection frequently triumphs over that of the ombiasses; and parents are known to cause their infants, when doomed to exposure, to be privately carried away, and nursed by faithful servants; while they endeavour, by sacrifices, to avert the malignity of the star which had presided over the birth of their offspring. Aged persons are never exposed, as in many savage nations, but are uniformly treated with great respect.

The ombiasses, or physicians, have much recourse also to incantations and charms; but sometimes make use of certain herbs which appear to possess medicinal qualities. In curing, particularly the venereal disease, which the visits of the trading vessels frequently introduce among the natives, they administer the leaves of a plant resembling phyllyrea, which the patient is directed to chew and swallow, while lying in a room kept warm by fires, so as to throw off the virus by a prolonged perspiration, or by the ulcers which, under this treatment, commonly form on the soles of the feet.

The religion of the people of Madagascar is a mixture of heathen superstitions with Jewish traditions and Mahometan observances. The Zaffe-hibrahim around Foul Point and the Bay of Antongil profess a greater respect for Moses than for Mahomet, and even the descendants of the Arabs have dropped the leading tenets of Islamism. Many of them are said to have no belief in a future state of existence, and the prevailing principle resembles that of Manichees. They address prayers, and offer sacrifices, however, only to the evil spirit and his associate demons. They abstain, in some districts, from the use of pork, observe the seventh day, and practise circumcision. The last-mentioned ceremony is observed with great solemnity, and generally in the month of May, when a number of children are brought to one place, and a feast is celebrated by their friends on the day preceding the operation. On the following day the children are assembled in a kind of temporary temple; and the precise time of commencing the ceremony is marked by the shadow of a man standing before the sun, which announces the critical moment, when it measures nine feet in length. Sacrifices are offered at their funerals, and provisions placed around the tombs. The memory of their deceased friends is regarded with the utmost reverence; and their most solemn oath is to swear by the souls of their ancestors. The following description, by Rochon, of a sacrifice on the ratification of a treaty, of which he was an eye-witness, may be given as a specimen of the religious rites of Madagascar:

"The orator slaughtered a victim, received the blood in an earthen vessel, and mixed with it sea-water, pimento, gun-flints broken and bruised very fine, and a small quantity of earth and gun-powder, moistened with rafia, or spirit made from the sugar-cane. Two leaden bullets served him to pound these different ingredients, in order to form a kind of beverage, which he wished the devil might convert into poison for all those, who, having drunk of it, should not adhere to their oath. He then took two lances or assagays, and dipped the points of them in the liquor; while John Harre (a Madagascar chief who ratified the said treaty with the French) sprinkled a few drops of it upon the ground. The orator, afterwards taking a knife in his right hand, and first invoking the god of the whites, and then that of the blacks, begged them, with a loud voice, to inspire into the hearts of both, peace, amity, concord, and sincerity. Then, striking with his knife the points of the two assagays, which he had dipped into the liquor, he denounced the most horrid maledictions and imprecations upon those who should infringe the treaty. He pronounced these imprecations three times, and with so much vehemence in his speech and gestures, that they made an impression upon the assembly, of which it would be impossible to convey an idea in words. Whilst the assembly were in this state of fear and terror, John Harre and the other chiefs, with a trembling hand, put about a spoonful of their disgusting liquor into a leaf of raven, and swallowed it with the most horrid grimaces. Their example was followed by the greater part of those who assisted at the ceremony; but some of the Frenchmen contented themselves with only feigning to do it. Rabesin (the orator) then proceeded to sacrifice the victims; and a grand feast, accompanied with dancing, music, and sports, terminated rather in a noisy but joyful manner this celebrated palavre."

In the ceremony of making a brother, which seems to resemble the bond of free-masonry, a tub full of blood is placed in the midst of the company, and a quantity of gunpowder, with one or two pistols, are thrown into it. The mixture is then stirred with a long rod of iron, and the point of this every man touches with his tongue. The natives consider the obligation of this rite to be so strong that they will do any service, and even lay down their lives for a stranger, who has thus become one of their brethren. Another ceremony, obviously of a religious nature, and bearing some resemblance to a sacred Christian rite, was also observed among the people of Madagascar. A company is collected, a sacrifice killed, and a table covered with banana leaves placed in the middle of the space where the assembly is held. On this is laid three small slices of bread, and pieces of the flesh of sacrifice opposite to the bread, together with a bottle of liquor. The master of the family then offers a prayer for a blessing on his children and friends; after which the bread is broken, and the whole of what is provided distributed among the company.

There are no records, and even few traditions concerning the history of Madagascar, previous to its discovery by the nations of Europe, and distinct from the settlements which have at various periods been partially formed on its coasts. Respecting the plans and procedings of its earliest visitors, the Portuguese, little authentic information is to be found; and it is chiefly through the French colonies of Mauritius and Bourbon, that any attempts have been made to acquire a knowledge of the island, or to open a friendly intercourse with its inhabitants. In 1642, a grant of the island was given to a mercantile company by letters patent from the French crown; and a person named Pronis, was commissioned to take possession of the country in the name of his sovereign. His first establishment was planned in a very advantageous spot, at the extremity of the province of Anossi, in the latitude of 24° 30′; but within the space of a month more than one-third of his followers fell victims to the unhealthiness of the climate; and he retired hastily with the remains of the colony to the peninsula of Thalonga, in latitude 25°, where he built Fort Dauphin on a commanding position, and in the vicinity of an excellent harbour. Pronis, however, having suffered the colonists, through his incapacity and indolence, to fall into a state licentious turbulence, and having excited the indignation of the islanders, by selling as slaves to the Dutch governor of Mauritius all the Madagasses in the service of the establishment, was superseded by the company in 1648. His successor Flacourt, who has published an account of his administration, and of the island, was a more energetic commander of his countrymen in the colony; but pursued, far beyond his predecessor, those measures of cruelty and oppression toward the natives, which have been too faithfully followed by the greater part of succeeding settlers. In 1667, the Marquis of Mondevergue, having been appointed to the general command of all the French settlements beyond the Equinoctial line, arrived at Fort Dauphin with a fleet and reinforcements; and by his judicious conduct was making no small progress in advancing the prosperity of the colony, and establishing amicable relations with the native chiefs, when he was succeeded, in 1670, by M. de la Haye, a naval captain, who speedily plunged the settlement into new contests with the Madagasses, and then withdrew with the greater part of his forces to Saurat. Hitherto the fury of the islanders against the settlers at Fort Dauphin had been restrained or repelled by the able assistance of a Frenchman named La Case, who had married a powerful princess of the country, and had always in spite of frequent injuries from the different governors, interposed his influence in Madagascar in defence of his countrymen. In a short time after the death of this adventurer, the native chiefs, utterly impatient of the oppressive yoke which they had borne, and burning with all the savage thirst of vengeance for the injuries which they had experienced, united against the wretched remains of the French colonists, and cut them to peices in one general massacre. The French had long regarded Madagascar as a station of the greatest importance to their Indian posessions; and had hoped, in their last attempt to form a settlement on its coast, that they were laying the foundation of an empire. They were extremely reluctant to abandon these flattering prospects, and were in fact necessarily dependant on the supplies from this island, for the subsistance of their settlement at Mauritius. Hence they did not fail to renew their exertions to maintain an establishment in Madagascar, and in 1768, particularly, a judicious plan of reviving the colony at Fort Dauphin was attempted to be put in execution by M. De Modaue, who proposed to secure the safety of the settlers, not so much by military assistance, as by cultivating the confidence of the natives, and to make use of their services rather as hired labourers than as slaves.

But it has been principally from the north-east part of Madagascar that the French colonies at the isles of Bourbon and France have drawn their supplies. Their most frequented ports at that quarter were Foul Point, St. Mary, and the Bay of Antongil; and in these three places they have repeatedly attempted to form establishments; but, exclusive of all the ordinary obstacles incident to colonies in their circumstances, they experienced the greatest interruption to the success of all commercial relations, from a piratical settlement on the isle St. Mary. This island, called by the natives Nossi-Hibrahim, is situated on the east coast of Madagascar, in 16° 13′ south latitude, opposite to the province of Ghalemboule, from which it is separated by a strait three leagues in breadth. It is 18 leagues from north to south, and 3 from east to west. One extremity extends to the bay of Antongil, and the other reaches within 11 leagues of Foul Point. It is surrounded by a reef of rocks, so as to be accessible to shipping only in a few places; and a great part of the interior is covered with hills, which give rise to numerous streams, which fertilize the soil around the shores. In this island the pirates, who had long infested the Indian seas, took refuge about the end of the 17th century, and succeeded, by contracting alliances with the natives, in securing their confidence and friendship. They assumed the manners and adopted the customs of the country; opened a lucrative traffic with the islanders for the necessary articles in repairing and victualling their vessels; and, though avowedly following an infamous profession, were, nevertheless, regarded by the Madagasses as much superior in honourable dealing to the crews of several European traders, who were too often accustomed to take refreshments by force, burning the villages, and butchering the inhabitants, when they failed to furnish the required supplies in due abundance, and with sufficient expedition. About the year 1722, however, the European companies concerned in the trade of India, formed a powerful association to free the seas from these formidable marauders; and succeeded, after a desperate and prolonged struggle, in destroying their principal means of annoyance. These banditti, being thus compelled to renounce their predatory pursuits, contrived to excite continual quarrels among the natives of Madagascar, and persuaded them to sell their prisoners as slaves to the European vessels which visited the island. This was a practice of which these islanders had hitherto testified the strongest abhorrence; but having once found it so ready a method, at the same time of gratifying their revenge and increasing their wealth, they have prosecuted the hateful traffic with a fatal perseverance, which almost threatened to depopulate one the most beautiful and fertile islands in the world. Among the descendants of these pirates at St. Mary, the French East India Company attempted to form an establishment about the middle of the last century; but the jealousy of the natives having again been roused by the imprudent and overbearing conduct of its leaders, the whole of the settlers were massacred in one night. As soon as this event, which took place on Christmas eve, 1754, was known at the isle of France, an armed vessel was dispatched to port St. Mary to take vengeance on the islanders, by sinking their canoes, burning their villages, and butchering as many human beings as fell into their hands. By the assistance of a French soldier, named Bigorne, who had acquired the language of Madagascar, and gained the confidence of the natives, a friendly intercourse between them and the colony of Mauritius was, in a few years, revived at Foul Point, but incessantly interrupted by quarrels and bloodshed. But, of all the schemes entertained by the French for the occupying of Madagascar, the most unwarrantable and ill-directed was the expedition under baron D'Aladar de Benyowski. This desperate adventurer, having escaped with twenty or thirty followers from the prisons of Kamschatka, made his way to the isle of France, and thence to Paris, where he solicited and obtained the general government of Madagascar, on the avowed plan of reducing the whole island by force of arms. Appointed to the command of this daring expedition, he arrived in the bay of Antongil, in 1777, with a body of troops, dressed and accoutred in such a manner as might strike terror, by their very aspect, into the hearts of the islanders. His soldiers were provided with enormous sabres, pistols in their girdles, formidable helmets, and other military terrors. As soon as he had landed, he took formal possession of the island, caused himself to be proclaimed governor-general, and traced out the plans of various fortifications. Having made war on the Madagasses, and exercising against them every species of cruelty, he became an object of universal execration. The natives fled in alarm into the interior of the island; a suspension of every kind of commerce every where followed; and Benyowski was known through the country by the name of the "wicked white man." His troops sunk under the unhealthiness of the situation which he had chosen for his town of Louisburgh; the agriculture, as well as the commerce of the colony, fell into the most languishing condition; and the requisite supplies for the Mauritius were entirely cut off. Yet did Benyowski continue in his dispatches, to boast of the towns, fortresses, and roads, which he was constructing in the island; and, upon repairing in person to France, found means to recommend himself to additional honours. Having there insinuated himself into the acquaintance of Dr. Franklin, he afterwards proceeded to America, where he projected new devices for gaining possession of Madagascar; and having arrived at the bay of Antongil in an American vessel, gave manifest indications of a design to render himself the independent sovereign of the island. In 1786, viscount de la Croix was sent from the isle of France, with a small detachment, to counteract his enterprises, and found him, in a great measure, master of Madagascar, the inhabitants of which, though alienated from his interests, were completely intimidated by his measures. Confident of his security, he made little opposition to the progress of the French detachment, till he was attacked in his fort at Louisburgh, where he was killed by a musket ball while in the act of firing a cannon from the walls.

About the year 1770, the Portuguese from Goa made an attempt to form a settlement at Cape St. Sebastian, in the north point of the island, with the view of establishing a mission rather than a factory; but their plan failed of success, and the district where they landed has for many years been occupied by a set of pirates, whose depredations have proved particularly fatal to the Comoro islands. These banditti are called Sekelaves by the Portuguese of Mosambique, but their proper name is Marati. They annually visit the Comoro islands for the purpose of procuring slaves, whom they sell to the French; and usually make the passage about the latter part of the south-west monsoon. They build huts around the towns which are walled, and remain blockading them till the end of the north-east monsoon, about eight weeks from the time of their arrival. They sail in large canoes, 45 feet long, by 10 or 12 wide, ingeniously put together on a construction similar to that of a whale-boat, and joined by wooden pegs driven into both edges of the planks. Every fifth year they send about 100 canoes, each containing from 15 to 35 men; but, in order to give the plantations time to regain a flourishing condition, to yield them provisions, they fit out only about 30 sail during each of the intervening years. By these expeditions, they have nearly depopulated the islands of Comoro, Mohilla, and Mayotta; and have reduced the towns of Johanna from twelve to two. Encouraged by their success against the last mentioned island, they ventured across the channel of Mosambique, in 1808, and took possession of one of the islands of Querimbo, desolating the country, and murdering all the inhabitants who fell into their hands. In 1807, they cut off a French ship bound to the isle of France, and massacred all who were on board. They carry cresses like the Malays, and make their attacks with the utmost ferocity. They have frequently threatened the Portuguese settlements on the coast of Africa, from which they have been in the practice of purchasing or carrying off slaves, whom they keep at Madagascar as a general depot, till they have an opportunity of conveying them clandestinely to the isles of Roderique, Bourbon, and Mauritius. A detachment of British troops was sent from the last mentioned island to Ova, about 300 miles from Tametavi, to attempt the suppression of this traffic; and the fort at Tametavi was previously occupied by a similar force, at the capture of the French settlements in the Indian seas. But, in March, 1815, the whole of these troops were massacred by the natives. One of the native chiefs, it appears, was displeased by the omission of a present to which he conceived himself entitled, and demanded a piece of blue cloth, which gave rise to some altercation. By the intervention, however, of the other chiefs, the affair was apparently made up; and the English were invited to attend an assembly of these chiefs next day, that all parties might be formally reconciled,—but, upon entering the place of meeting, they were instantly assaulted and put to death. The gardener alone escaped to the pilot-boat alive; but died, on the passage to Mauritius, of the wounds which he had received. Notwithstanding this renewed instance of the irritable and vengeful temper of the Madagasses, measures are still in contemplation for opening a friendly intercourse with the island, and hopes still entertained of accomplishing the civilization of the natives. Two sons of a king in Madagascar are said to have been received at Port Louis, for the purpose of being educated under the patronage of the governor—an event which may contribute, in no small degree, to the safety and success of future visitors to the island. Some of the missionary societies in England are also proposing to attempt a settlement on Madagascar; but not, it is to be hoped, till there be some prospect of protection to the persons of their missionaries from the fury of its savage inhabitants. Madagascar has, in the mean time, been annexed to the British empire as a dependency of Mauritius. See Rochon's *Voyage to Madagascar;* Flacourt's *Account of Madagascar;* Drury's *Adventures in Madagascar;* Benyowsky's *Memoirs*, vol. ii.; and Salt's *Voyage to Abyssinia.* A work, entitled "The Great Dictionary of Madagascar," containing the languages of the island, and a collection of all publications relating to its history, was advertised at Port Louis in 1818. (*q*)

MADDER. See DYEING.

MADEIRA, is an island in the Atlantic, belonging to Portugal. It is of an oval form, and is about 30 miles long, and about 15 or 16 miles at its greatest breadth. The highest mountain in the island, called the Pico Ruivo, is 5068 English feet high. This peak is situated about the eastern extremity of the mountainous part; and there extends from it, to the westward, for about 20 miles, a sort of table land, called Paulo da Serra, which is in some places extremely narrow, and so tempestuous during the winter, that it does not contain a single habitation.

Agriculture is here in a very imperfect state. Though the island is capable of producing much more grain than is necessary for the support of its inhabitants, yet it actually produces no more than supplies them for three or four months. The principal productions of the island are, a little wheat, rye, sugar, coffee, West India corn, (which has sometimes 16 heads upon one stem,) the *Arum esculentus*, the *Convolvulus batatus*, kidney beans, and arrow root, or *Maranta arundinacea*. The *Arum esculentus* is the principal article of food among the lower classes, and is preferred to any other; and the *Convolvulus batatus* is also generally used for the same purpose. The climate is so fine, that three crops of potatoes have been gathered from the same ground in one year. Pine apples here grow in great abundance; and cabbages often swell to such an enormous size as to weigh 100 lbs. Rural labour is performed by oxen; for there are no horses in the island but a few small ones from the Azores.

Above the region of the pines, the whole island is surrounded with a belt of chesnut trees; and in the valleys, above the region of the chesnuts, excellent early apples grow in great abundance.

The mountain forests of Madeira yield some of the finest trees in the world: the principal of which are, the *Laurus Indica*, which is nearly as good as mahogany; the *Olea excelsa*, the wood of which is so heavy as to sink in water, and which grows as hard as marble, and is used for planes; the *Laurus fœtens*, the smell of which is most intolerable, like that of the worst animal excrements; and the *Erica arborea*, or heath tree, which grows among the mountains, and is sometimes seven feet in circumference. Yew trees formerly abounded in the island, but they are now extinct. They are, however, often found under ground, at the places which have been laid bare by inundations. Among the other vegetable productions of Madeira, is the *Lichen fuciformis*, or orchill, which is used as a dye, and gathered in the Salvages.

The principal animals in Madeira are, rabbits, ferrets, wood-cocks, snipes, red-legged partridges, and quails. The coast supplies plenty of fish, particularly the Jew fish, reckoned the best for the table, John Dorees, and red mullets. The beef and mutton of the island is reckoned lean and tasteless; the common domestic fowls are small, but the ducks and turkeys are excellent, the last being as good as those of Norfolk.

The great production of Madeira is wine, which is known over all the civilized world. Upwards of 40,000 pipes of it are annually exported, one-half of which goes to the British settlements in the East and West Indies. The best vines grow on the south side of the island, and on the side of the hill which points to the east. The wine on the north side of the island, which is inferior in quality, is generally made from vines which grow upon chesnut trees; and sometimes as many grapes have been gathered from one chesnut tree as will make a pipe of wine. The price of the wine at the vine-yards is from 5*l*. to 50*l*. per pipe.

The wine of Madeira is classed under the following qualities, namely,

London particular - - -	First quality.
London market - - - -	Second quality.
India market - - - - -	Third quality.
New York market - - - -	Fourth quality.
Cargo - - - - - - -	Fifth quality.

Besides these wines, there are Sercial, sweet Malmsey, dry Malmsey, and Tinto, or red wine.

The quantity of wine shipped from Madeira to India in 1805, was about 6260 pipes. The customs levied by the British consul, for Madeira wines returned for home consumption in Great Britain, amounted, during the 14 years from 1796 to 1800 inclusive, to 632,040*l*., the annual amount increasing rapidly.

The other exports of Madeira are chesnuts, walnuts, and preserved citrons. The inhabitants import Indian corn and wheat from America, great quantities of salt fish from Newfoundland, and fresh meat and live sheep and oxen from the states of Barbary.

The total amount of the imports from England to Madeira, in the 17 years from 1793 to 1809 inclusive, was 3,278,043*l*.; and the amount of exports to England, during the same period, only 216,167*l*. In 1806, the imports from England consisted of

British merchandise	*L* 171,082
And foreign merchandise	16,048
	L 187.130

In the year, from the 30th September 1805 to the 30th Sept. 1806, the Americans imported into Madeira,

	Dollars.
Domestic produce	528,375
Foreign merchandise	62,194
	590,569

They generally carry back wine, which is consumed in America, and partly carried to the East and West Indies.

There are few manufactures carried on in the island. The women weave the finest webs with a paltry machine, which they carry about with them. Instead of preparing the threads with batter, as is done in this country, they use a decoction of the *Malva campestris*, and the linen is boiled in it. In the management of their bees, they take away the honey without destroying the insect. A tube, containing dry ox-dung, is used for that purpose. The dung is set on fire, and the smoke blown into the hive. The bees immediately leave it, and return when the honey has been removed.

According to the Honourable Henry Grey Bennet, who examined the mineralogy of this island, and whose account we shall slightly abridge, "it consists of a succession of lofty hills, rising rapidly from the sea, particularly on the eastern and northern extremities. The summits of many of these ranges present the appearance of what has been called a table land; yet occasionally the forms are conical, and surmounted by a peak, which, in some instances, was found to be of columnar basalt. Deep ravines or valleys descend from the hills to the sea, and in the hollow of most of them flows a small river. The soil of the island is clay on the surface, and large masses of it as hard as brick are found underneath. Though there are not at present any existing volcanoes in the island, yet the remains of two craters are to be seen, one on the eastern, the other on the western side, the largest being about four English miles in circumference. Every thing wears marks of having suffered the action of fire; yet no sulphur is found.

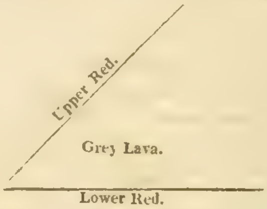
" The varieties of strata are four. Three of them were invariably alternating in the same order. The first or lowest lava is of a compact species, containing few, if any extraneous substances, is of a blue colour, and of a remarkable fine grain. Upon that the second, which is a red earthy friable lava, rests; sometimes separated by beds of clay mixed with pumice, and layers of black ashes and pumice. This red lava contains minute pieces of olivine; sometimes it assumes a prismatic form, and in one place was of a moderate degree of hardness: the principal springs of water in the island issue from this stratum. On the top is the third, a greyish lava, generally compact, though, at times, near the surface very cellular, and containing much olivine. This lava takes principally the prismatic form of basalt. I have seen it in the most perfect prisms from 30 to 40 feet or more in height, the surface being covered with scoria, ash, and pumice. These masses of lava contain more or less of what I consider to be olivine, and occasionally carbonate of lime and zeolite.

" The fourth species of lava is of a coarse grain, is used for the making of walls, and the commonest and poorest houses are built of it, the blue and grey lavas being used for the copings, &c. It works easier than the two other kinds above mentioned, is more friable and soft, and its colour is a mixture of brown and red. It is a stratum by itself, and it did not seem to have any connection with the other three kinds.

" These are the principal stratified lavas that the island affords; but in the beds of the rivers, particularly in that which flows in the valley of the Corral, several varieties occur in isolated masses, containing olivine and zeolite in greater or less quantity, and exhibiting detached portions of strata.

" From the beach before Funchal to Illhoo Castle, and beyond it to the land called the *Punta de la Cruz*, the general character of the coast is as follows: The red stone is the apparent base upon which rests a bed of grey prismatic lava, the stratum being sometimes from 40 to 100 feet in depth. At times this grey lava rests upon a deep bed of ashes and pumice, agglutinated together like the *peperino* and *puzzolano* in the vicinity of Naples. The scoria at the surface is remarkably thick, and all the upper parts of the lava appear to be cellular. The general dip of the lava on the coast near Funchal is to the north, but near the fort of Illhoo it forms, with a mass of pumice that is intersected with slight veins of carbonate of lime and zeolite, a rapid angle or curve of declination to the east. To the westward of the fort, the lava is not found for a little distance, and there is nothing but deep beds of pumice and the agglutinated mass above mentioned. These beds of pumice are of various thickness, the deepest appearing to be about four feet, and alternating with the stratum called *peperino*. In different cavities of the pumice bed, there are large deposits of black ashes. Towards the extremity of the strata, the red stone appears on the surface in a more solid state, and lies in prismatic masses, the prisms being small, and not exceeding a few inches in diameter. Their substance is brittle, and crumbles with ease. This stratum of red lava is of a short continuance. Passing a small brook, it dips rapidly to the westward; and, in its place, the grey lava is found in a confused though sometimes prismatic form, and rises from the beach, while the red lava still runs along the surface to the height of near 100 feet, the top being covered with a thick scoria.

" There is also in the vicinity of Funchal, to the eastward of the town, a fall of water, which, independent of the romantic beauty of the situation, merits being visited, on account of the exposure of the two strata of lava in their relative position. The hills are composed wholly of lava, sometimes of a confused, sometimes of a prismatic, formation, the red and grey lavas being visible on both sides of the valley. Near the head of it, a short distance from the cascade, the red stratum is at the bottom, and about 60 feet higher it re-appears, and again about 200 feet higher, alternating with the grey lava. The upper red lava dips rapidly to the south, and the strata are disposed in the following manner:



" The rock, down which the cascade falls, is also intersected with a red stratum of about three feet wide, that traverses it, and dips to the westward, and is broken off by a broad dike of grey lava. It appears about 30 feet higher, and dips again to the westward. The substance of the red rock in this place is hard, and it breaks into a columnar form, being by far the most compact of the red strata I met with in the island."

There are three principal rivers, which flow from the sides of the Pico Ruivo. The waters of these and the other little tributary streams are diverted from their channels by long established regulations, and are made to fertilize lands which would otherwise have been entirely useless.

The principal town in Madeira is Funchal, which is situated in a valley on the south coast. The streets are straight, and the houses neat and comfortable. The principal public buildings are, the governor's house or castle; the bishop's palace; the cathedral, which is a superb Gothic building, having its roof of cedar, of exquisite workmanship; the custom-house, surrounded by a rampart mounted with cannon; the Jesuits' church; and several other churches. There is also an excellent hospital here. Funchal is strongly defended by means of four forts, namely, St. Jago on the eastern extremity of the beach; Lorenzo, within 200 yards of the western extremity of the town; the Peak castle, at the northwest angle of the town, on a hill about half a mile from the shore; and a fourth upon the Loo Rock, about 400 yards from the shore. There is also a strong wall to the sea, by which the forts are connected.

The number of inhabitants in the island of Madeira is about 100,000. The natives are a mixed race. The number of clergy, including monks and nuns, does not exceed 300.

Beside the island of Madeira, this group comprehends the island of Porto Santo, to the north-east of Madeira; and the Desertas to the south-east. Porto Santo is about 10 miles long, and 2 or 3 broad, and contains about 3000 or 4000 inhabitants, who make wine. This island supplies Madeira with barley and with white lime. On the south-west side there is an excellent road, where ships of 500 tons burden may ride with safety. The Desertas are uninhabited, and are merely high rocky cliffs, the abode only of goats and rabbits. The Procellaria glacialis is killed here in great quantities, and carried to Funchal, where they are salted. The Salvages are bare rocks abounding in gypsum, which is imported into Madeira for the purpose of fining their wine.

The principal proprietors in the island of Madeira are Mr. Carvalhal and Mr. De Frittas, men of high character and talents. See the *Transactions of the Geological Society*, vol. i. p. 391; and Milburn's *Oriental Commerce*, vol. i. p. i.

For the principal facts in the preceding article, the Editor has been indebted to Dr. Shuter, who resided many years in the island. Long. of Funchal, 17° 6′ W. and Lat. 32° 37′ N.

MADELY. See Shropshire.

MADHOUSE. See Insanity.

MADRAS, or Fort George, the principal settlement of the British East India Company, situated in North Lat. 13° 4′, and East Long. 80° 33′, on the east side of the peninsula or coast of Coromandel, was first established in the year 1639. The first English factory in the Carnatic had been erected, in 1625, at Armegum, about 66 miles north from Madras; and its chief, Mr. Francis Day, having received permission from Sree Rung Rayeel, of the Hindoo dynasty of Bija Nagur, to build a town and fort on the site of the present city of Madras, proceeded, without waiting for instructions from the Directors, to found the new settlement. The fortress which he constructed, and which he named Fort St. George, was speedily surrounded by an Indian town; and the whole territory included in the grant, extended one mile inland, and five miles along the shore. The Hindoo prince above mentioned, had expressly enjoined that the place should be named after himself Sree Runga, Rayapatam. But the local governor, or naik, had previously intimated, that, in honour of his father Chenappa, it should bear the name of Chenappatam; and, by this appellation, it continues to be known among the natives of the surrounding district. In 1653, the agent and council of Madras were raised to the rank of a presidency; but their civil establishment consisted only of two factors and a guard of ten soldiers. In 1671, the sovereign of the Carnatic made over to the Company his moiety of the customs of Madras, for the fixed rent of 1200 pagodas per annum; in 1687, the population of the fort, city, and adjacent villages, was reported, in the public letter, to amount to 300,000; and, in 1696, the revenue produced by the taxes was not less than 40,000 pagodas. In 1702, the settlement was blockaded and threatened with destruction by Aurengzebe's general, Daoud Khan; and, in 1708, was not less in danger from internal dissentions, in consequence of a dispute among the native inhabitants for precedency. After the junction of the rival East India Companies, in 1708, no authentic annals of Madras are to be found till the year 1744, when it contained 250,000 native inhabitants, and 300 English, of whom 200 only were soldiers of the garrison. In the month of September, it was besieged by the French from the Mauritius, under M. de la Bourdonnais; and, after a bombardment of three days, was compelled to surrender. The plunder realized by the captors was about 200,000*l.* and the town, by the terms of capitulation, was ransomed for 440,000*l.*; but the agreement was afterwards broken by M. Dupleix, and all the British inhabitants of every description compelled to leave the place. It was restored to England at the peace of Aix-la-Chapelle; and, when evacuated by the French in 1749, was found in a very improved state as to its fortifications. But, though greatly strengthened, it was still incapable of making an effectual resistance to a regular European force; and, in 1756, in the apprehension of another attack from the French, the greatest exertions were made to place it in a proper state of defence. Before these works were completed, the expected enemy approached, in December, 1758, under M. Lally, with a force of 3500 Europeans, 200 Seapoys, and 2000 native and European cavalry; while the garrison of Madras consisted only of 1758 Europeans, 2220 Seapoys, and 150 European inhabitants, which last class were appropriated, without distinction, to serve out stores and provisions to the garrison. The siege was carried on during the space of two months with the utmost skill, vigour, and bravery; but the defence under Mr. Pigot the governor, and Colonel Lawrence the commander of the garrison, was so able and resolutely conducted, that the assailants were obliged to retreat with the greatest precipitation, leaving all their sick, the greater part of their stores, 52 pieces of cannon, and 150 barrels of gunpowder. Since this memorable resistance, Madras has never sustained any external attack, though twice threatened by Hyder Ali; and the strength of its works now secures it completely against the utmost efforts of any native force.

From being originally a petty factory, with a territory five miles in length, by one in breadth, it has become the capital of an extensive region, comprehending the whole of the Indian peninsula south of the Krishna river, and also a large province in the Deccan, named the Northern Circars. Within these boundaries are three native princes, the Rajahs of Mysore, Travancore, and Cochin, who collect the revenues, and exercise a certain degree of power in the internal government of their respective states; but, with regard to external politics, they are entirely subordinate to the British government, being protected by a subsidiary force, and furnishing on their part large annual contributions. The rest of the country is under the immediate jurisdiction of the governor and council at Madras; and has been subdivided into twenty-one districts, namely, Ganjam, Vizagapatam, Rajamundry, Masculipatam, and Guntoor, forming the Northern Circars; Nellore and Ongole, northern division of Arcot, Trichinopoly, and Tanjore, in the Carnatic; Dindigul, Tinnebelly, Bellary, Cudapah, Seringapatam, Salem, and Kristnagherry, Coimbetoor, Canara, Malabar, and Madras, chiefly in Mysore. Of all these districts, the superficial extent has been estimated at 125,000 geographical square miles; and their united population at twelve millions, exclusive of the subjects of the Mysore, Travancore, and Cochin princes.

In the greater part of these provinces, before they came under the British government, the same system of landed property and revenue-policy prevailed. The land was the property of government, and of the ryots or cultivators; but the share of the government absorbed so much of the landlord's rent, that the ryots had little more interest in the soil than that of hereditary tenancy. The government share for rice lands was generally received in kind, at the rate of from 40 to 60 per cent. of the gross produce, after deducting certain portions before the threshing of the grain; but, from other grain-land, it was usually received in money, varying in amount with the produce. Besides this land-revenue, the public receipts of the Madras government arise from customs on the imports by sea; from duties levied on the inland trade; from a monopoly of the manufacture and sale of salt; from licenses for the manufacture and sale of toddy and arrack, and in some places also of betel and tobacco; from stamp duties, post office, and fees of judicial proceedings. The following statement shews the revenues and charges of the presidency from all sources, for the year 1808-9.

Revenues.		*Charges.*	
Post Office	*L.*16,808	Post Office	*L.*19,926
Customs	152,958	Revenues and Customs	333,024
Carnatic	1,016,679	Carnatic	333 613
Tanjore	431,405	Tanjore	130,685
Mysore	1,540,228	Mysore	208,519
Nizam	681,807	Nizam	77,551
Dutch Settlements	2,727	Dutch Settlements	9,336
Travancore	6,504	Civil and Judicial	493,548
Land	1,057,628	Military	3,143,575
Farms and Licences	61.599	Buildings and Fortifications	185,966
	*L.*4 968,321		*L.*4,935,743

Total of Charges	*L.*4,935,743
Interest on Debts	495,408
	5,431,151
Revenue	4,968,321
Deficiency	*L.*462,830
Debt owing by the Company at this presidency in 1809	*L.*7,059,679
Amount of assets, debts, &c. belonging to the Company at the same period	9,183,682
	*L.*2,124,003

The company are possessed also of property to a considerable amount, in plate, household furniture, guns on the ramparts, arms, military stores, and buildings, which, from not being considered as immediately available, is not inserted among the assets. In 1811, the number of civil servants on the Madras establishment was 206, and their pay, &c. 470,346*l.* per annum; the number of chaplains, 15, and their pay 14,300*l.*; the number of surgeons, 101, and their pay 57,890*l.*; the number of military officers, 1347, and their pay 554,481*l.* The number of regular troops of all descriptions then serving under the presidency, amounted to 50,456 men. Unless in the hills of the Northern Circars, and a few other places, no military force is maintained by native individuals, whose turbulent retainers were continually engaged in petty wars with each other, by which the fields of the cultivator were laid waste, and every species of property destroyed or plundered. This unruly and restless spirit of the Polygars and other chiefs, which was peculiarly prevalent on the coast of Coromandel, is gradually yielding to the peaceable habits of the landholder; and the husbandman is enabled to pursue the culture of his fields without danger or apprehension. Any occasional recurrence of the former evils is promptly suppressed by the vigilant administration of a vigorous government, keeping every other power in due subordination, and affording equal protection to all ranks of its subjects.

A supreme court of justice is established at Madras, on the model of that of Fort William in Bengal. It consists of a chief justice, and three other judges, who must have been barristers of at least five years' standing, and who are appointed by the king. The salary of the chief justice is 6000*l.* per annum; and that of the other judges 5000*l.* each, at the exchange of eight shillings per pagoda. Should these judges, after seven years' service in India, return to Europe, they are entitled to pensions out of the territorial revenues, not exceeding 1600*l.* to the chief judge, or 1200*l.* to the junior judges. The law-practitioners attached to this court are seven attornies and four barristers.

The commerce of Madras, owing to the want of a secure port, and of navigable rivers, is much inferior to that of the two other presidencies. The Carnatic province, also, is generally sterile in comparison with Bengal; and produces none of the staple articles in such quantities, or at so low a price, as to maintain a competition in the foreign markets. The staple article of export by the East India Company is piece goods.

The following details of the private trade during 16 months, from January 1st, 1811, to April 30th, 1812, (which, however, was accounted rather an unfavourable year,) may furnish an idea of the commercial transactions in the presidency.

From America, the total value of imports, during the above-mentioned period, consisting principally of the inferior sorts of wine, gin, brandy, hams, tongues, and other provisions, was 104,017 arcot rupees; and that of the exports to America, consisting of the produce and manufactures of the districts under the Madras presidency, 374,579 arcot rupees.

From Batavia, the value of imports, consisting principally of prize sugar, sent by the agents of the captors, with a little sugar-candy and tutenague, was 48,356 arcot rupees; that of the exports to Batavia, composed chiefly of piece goods, was 259,576 rupees, besides a re-export of goods, chiefly wines and other European articles, for the Europeans in Java, to the amount of 51.555 rupees.

From Bengal, the value of imports, consisting almost uniformly of grain, particularly rice, raw silk, canvas, piece-goods, muslins, coarse shawls, long-pepper, sugar, borax, saltpetre, wines, and precious stones, was 3,004,180 arcot rupees; that of the exports to Bengal, consisting chiefly of some red-wood, coloured piece-goods, and salt, was only 130,507 rupees, besides a considerable re-export trade; but the principal returns from Madras to Bengal, for its imports, are made in bills. From Bombay and Bassorah, the value of imports, consisting principally of dried fruits and drugs from the former, first received there from the Persian and Arabian gulfs, besides cotton goods first received from Bengal and China; and from the latter place, of dried fruits, hing, mandesty, brimstone, and horses, was 162,861 arcot rupees; that of the exports to Bombay, consisting chiefly of some chintz and coloured turbans, and a small proportion of long cloth, was only 30,569 rupees.

From the Brazils to Madras, there is very little commerce, as the Portuguese vessels usually proceed directly to Bengal, where the articles calculated for their markets, namely, fine silks and piece goods, are procured on more reasonable terms than at Madras.

From Ceylon, the value of imports, consisting of arrack, for the use of the navy and European troops, and a number of articles for re-exportation to China, such as biché de mer, shark fins, ebony, chayroot, palmeras, and reepers, was 743,859 arcot rupees; that of the exports to Ceylon, principally European and China articles re-exported for the consumption of the Europeans on that island, was only 18,055; the supplies of grain required by Ceylon being chiefly furnished from Bengal.

From China, the value of imports, in the usual China goods, such as tea, sugar, nankeen, porcelain, alum, camphor, arsenic, tutenague, China-root, galengal, piece-goods, stationery, &c. was 1,336,948 arcot rupees. That of the exports to China, consisting chiefly of cotton, but less than usual, owing to the failure of that crop in the southern districts; and re-exports, especially of Ceylon produce, was 918,662, besides some ebony and other articles, which made up the difference.

From London, the value of imports, consisting of the investments by the captains and officers of the Company's ships in the various European goods, metals, naval stores, wine, &c. was 1,767,204 arcot rupees. That of the exports, namely, indigo, forming about one-half of the whole, piece-goods, and rough diamonds, was 979,000 rupees, besides considerable re-exports of prize spices and pearls.

From Madeira, wine was imported to the value of 60,378 arcot rupees.

From the Malabar coast, there was a small import of pepper, timber, coir, cordage, &c. amounting in value to 11,410 arcot rupees.

From Manilla, the value of imports, in soft sugar, indigo, and treasure, was 225,964 arcot rupees. That of the exports, in various descriptions of piece-goods and cotton, the former for Spanish America, and the latter for China, was 572,483 rupees.

From Mauritius and Bourbon, the value of imports, in coffee, cloves, brandy, copper, iron, lead, &c. was 202,096 arcot rupees. That of the exports, consisting of long cloths, blue cloths, handkerchiefs, muslins, ginghams, punjum cloths, salampores, with a small re-export of European and China goods, was 1,157,646 arcot rupees.

From Pegu and the Birman empire, the value of imports, chiefly in timber and horses, was 495,643 arcot rupees;—that of the exports, almost entirely of piece-goods, with a few re-exports of metals, spices, glass-ware, and naval stores, was 215,006 rupees.

	Arcot Rupees.
Total exports in private trade, exclusive of treasure	12,869,049
Total of imports	12,039,679
Balance in favour of the export trade	829,370

	Arcot Rupees.
Treasure imported into Madras and its subordinate ports	4,176,029
Treasure exported	318,577
Surplus of treasure imported	3,857,452

The value of the investment exported by the East India Company from Madras, during the official years of 1811-12, was as follows:

To London.

Cochineal	12,454	
Hemp	2,272	
Piece-goods	4,416,163	
Saltpetre	22,545	
Sugar	10,227	
		4,463,661

To St. Helena.

Cholum seeds	40	
Piece-goods	6,752	
		6,792

To the Isle of France.

Piece-goods		18,829
	Arcot rupees,	4,489,282

At Madras, accounts are kept in star pagodas, fanams, and cash. Eighty cash make one fanam; 12 fanams a rupee; and 42 fanams a star pagoda, in the bank of the European merchants; but, among the natives, there are 12 fanams 60 cash to a rupee, and 44 fanams 50 cash to a pagoda. The pagoda fluctuates in the market from 44 to 46 fanams. The current coins are, various sorts of pagodas, arcot rupees, single and double fanams, and copper coins of 20, 10, 5, and 1 cash each. For adjusting the customs,

The pound Sterling is valued	at	2 pagodas 21 fanams.
The Spanish dollar	at	28 fanams 40 cash
The China tael	at	1 pagoda.
The pagoda	at	3¼ Sioca rupees. 3½ Bombay rupees.

100 Star pagodas, in the Company's accounts, at 425 current rupees.

The town of Madras stands close upon the shore, and is very unfavourably situated, either for the purposes of commerce, or the conveniences of a capital. The coast forms nearly a straight line, swept by a strong current, and without any port for shipping. Large ships generally moor about two miles from the shore, in nine fathoms, and with the flag-staff W. N. W.; but the station in the roads becomes very hazardous from the beginning of October to the end of December. There is also very great difficulty, and even no small danger, in landing from the vessels, in consequence of a tremendous surf which breaks upon the shore, even in the mildest weather, and which no boats of European construction are able to withstand. The boats of the country, generally called accommodation boats, which are used for crossing those dangerous waves, are singularly formed without ribs or keel, with flat bottoms, and without any iron in their whole fabric. Their planks, which are very thin, are sewed together, having straw in the seams instead of caulking; and are thus so flexible, as to yield like leather to the impulse of the breakers. They are very large and light, and have a bench at one end, covered with cushions, and protected with a curtain, so that passengers may be kept dry, while the surf is breaking around them. The rowers sit on bars on the very edge of the boats, and are entirely naked, except a turban on the head, and a half handkerchief about the waist; while their bodies are in a manner whitened by the crust of salt left upon them by the sea-water. "While I was observing," says Mrs. Graham, when describing her landing in one of the boats, "its structure and its rowers, they suddenly set up a song, as they called it; but I do not know that I ever heard so wild and plaintive a cry. We were getting into the surf; the cockswain now stood up, and with his voice and his foot kept time vehemently, while the men worked their oars backwards, till a violent surf came, struck the boat, and carried it along with a frightful violence; then every oar was plied to prevent the wave from taking us back as it receded, and this was repeated five or six times, the song of the boatmen rising and falling with the waves, till we were dashed high and dry upon the beach." The boats belonging to ships in the roads sometimes anchor on the outside of the surf, and wait for the country boats from the beach, to convey their passengers ashore. When the weather is so tempestuous as to render it hazardous even for the country boats to pass and repass, a flag is displayed at the beach-house, to caution all persons on board the vessels in the roads from attempting to land. The fishermen, and others of the lower class who are employed on the water, use floating machines of very simple construction, named catamarans; which are formed of two or three light logs of wood, eight or ten feet long, lashed together, with a small piece of wood between them, to serve as a stem-piece. They contain two men, who launch themselves through the surf by means of their paddles, to fish, or carry letters, or convey small refreshments to ships, when no boats could venture out. These men wear a pointed cap made of matting, in which the letters are secured from damage, however often the rowers may be covered by the water, or washed from the catamaran. They regain the raft by swimming, though sometimes prevented, by falling a prey to the sharks; and, to encourage them in so dangerous a service, medals are conferred on those who distinguish themselves by their care in conveying papers through the surf, or by their exertions in saving persons in danger.

The approach to Madras from the sea, presenting low, flat, sandy shores to the north and south, with a few small hills inland, exhibits a striking appearance of barrenness; but the prospect greatly improves on a closer inspection. The beach, covered with moving crowds; the public offices and storehouse, which are fine buildings, erected near the shores, supported on arched bases, with colonnades to the upper stories, and covered with the hard, smooth, and beautifully polished shell-mortar of the country; the fortification of St. George within a few yards of the sea; the minarets and pagodas, mixed with trees and gardens, seen at a distance, present altogether a very interesting appearance. Fort George, which was planned by Mr. Robins, is, in its present state, a strong handsome fortress, neither so extensive nor so regular as Fort William at Calcutta; but from its greater facility of being relieved by sea, and the nature of the ground, which allows an enemy little choice in conducting his attack, it is deemed equal in strength, besides the farther convenience of requiring a much smaller garrison. In the middle of the present fortress stands the original fort first erected in the settlement, but now mostly converted into government offices and town residences for some of the civil servants. To the south of the fort stands the church, and to the north of it the exchange. On the last mentioned building a lighthouse was erected in 1796, the light of which is 90 feet above the level of the sea, and may be seen from a ship's deck 17 miles at sea. The government house, a large and handsome edifice, is in the Choultry plain, on the edge of the esplanade; and near to it are Chepauk gardens, the residence of the Nabob of the Carnatic. The Choultry plain commences about a mile and a quarter south-west of Fort George, from which it is separated by two small rivers; one of which, the Triplicane, winding from the west, reaches the sea about 1000 yards to the south of the glacis; and the other, coming from the north-west, and passing the western side of the black town, proceeds eastward within 100 yards of the sea, washing the foot of the glacis, thence continuing in a southerly direction parallel with the beach, joins the mouth of the Triplicane. The plain extends two miles to the westward of the enclosures which bound the St. Thomé road, and terminates on the other at a large body of water called the Meliapour bank.

Madras has no European town, except a few houses in the fort. The settlers reside entirely in their garden-houses, repairing to the fort in the morning for the transaction of business, and returning home in the afternoon. These garden-houses are generally only of one story, but of a pleasing style of architecture. Their porticoes and verandahs are supported by chunamed pillars; and their walls are of the same materials, either white or coloured. They are closely surrounded by plantations of trees and shrubs; but, in the sandy soil, flowers and fruits are not easily raised. The floors are covered with ratan mats; and, during the hot winds, mats made of the roots of cusa grass, which has a pleasant smell, are placed against the doors and windows, and constantly watered; so that the air which flows through them spreads an agreeable freshness and fragrance throughout the rooms, which, without the cooling influence of these mats, would be as oppressive as a furnace.

The black town of Madras stands to the northward of the fort, from which it is separated by a spacious esplanade. It was formerly surrounded by fortifications sufficient to resist the incursions of cavalry; but which, having long become unnecessary, are now much neglected. Like other native towns, it is an irregular and confused mixture of brick and bamboo houses, and makes a better appearance at a distance than when closely inspected. In this town reside the native Armenian and Portuguese merchants, and also many Europeans unconnected with government. In 1803, a navigable canal was opened from the black town to Ennore river, 12 feet deep, 40 broad at the top, and 10,560 yards in length. By this canal, boats go to Pulicat, from which Madras is supplied with charcoal.

The new church, lately built on Choultry plain, is a beautiful specimen of Ionic architecture. The naval hospital at Madras is a large and handsome building, with a large platform on the top, where the convalescents take exercise, and enjoy the fresh air. There is an excellent garden, and a rope-work, attached to the hospital, which furnishes employment to the invalids. The botanical garden, which the late Sir James Anderson had planted at a vast expense, was almost entirely destroyed by a violent hurricane in 1807, and is now in a state of ruin. But a few of the useful plants still survive, especially the nopal, (cactus) an excellent anti-scorbutic, which is furnished to all the king's ships on the station. Among the charitable institutions of the place are a male and female orphan asylum, both of which are well conducted, the girls being instructed in all kinds of needle-work, and the boys brought up to different trades. The pantheon, an elegant edifice, used as a free-masons' lodge, contains a ball-room, a theatre, card-rooms, and verandahs. Among the public places may be mentioned the Mount Road, (leading from Fort George to St. Thomas' Mount,) which is smooth as a bowling-green, and planted on each side with banian and yellow tulip trees. On this road, about five miles from Fort George, is a cenotaph erected to the memory of Lord Cornwallis, on which a vast sum of money was expended.

The country around Madras is almost as level as Bengal, and in general exhibits a naked, brown, dusty, plain, with few villages, and with no other relief to the eye except a range of abrupt detached hills to the south. The roads in the immediate vicinity are kept in excellent repair, and are ornamented with borders of shady trees.

The huts, seen at a distance, are covered with tiles, and have a better appearance than those of Bengal; and the inns and choultries, which are common on the road, evince an attention to travellers not to be found in that province. The soil in the vicinity of Madras, when well cultivated, produces good crops of rice, provided the usual quantity of rain falls in the wet season; and, in some places, the industry of the natives creates, by means of irrigation, a refreshing verdure. A considerable part of the country, though at present naked, is considered as capable of raising trees and hedges; and shews symptoms of being in a progressive state of improvement. Near to Condaturu, particularly, it assumes a very pleasing aspect. Numerous small canals, from the Saymbrumbacum-tank, convey a constant supply of water to most of the neighbouring fields, without the trouble of machinery; and two crops of rice are thus produced in the year. The cattle in the neighbourhood of Madras are a small breed of the species common in Deccan, but larger than those which are reared in the southern parts of Bengal. Buffaloes of a small size are generally used in carts in the vicinity of the town. Meat, poultry, fish, and other refreshments for shipping, may be procured in sufficient quantity, but neither of so good a quality, nor at so cheap a rate, as in Bengal. The water is excellent, and is supplied by the native boats at specified prices. Wood and fuel are scarce, and of consequence dear. On account of the higher price of provisions, wages are also higher than at Calcutta; but fewer servants are kept, while masters are as well served. Household servants receive from two to five pagodas per month; and the hire of a palankeen is four and a half pagodas per month. For the field service, bearers receive each two pagodas monthly; but, at the presidency, only one and three-fourth pagodas. The men servants are chiefly Hindoos; but a great proportion of the female servants are native Portuguese. On landing at the town, passengers are immediately surrounded with servants of all kinds pushing for employment; especially by dobashies, who undertake to act as interpreters, to make all sorts of purchases, to provide servants, palankeens, tradesmen, and to transact whatever business a stranger may require. There are numbers of French pedlars from Pondicherry, with boxes of lace and artificial flowers, chiefly made by the ladies of the decayed French families in that settlement; and a class of Mahomedans also go about selling moco-stones, garnets, coral, petrified tamarind-wood, (found in the sands around Madras,) mock-amber, (the gum of a tree in the Malabar forests,) and a variety of other trinkets. The Madras jugglers are celebrated all over India, both for their sleight of hand, and for their feats of agility; and in their exhibitions they are commonly naked from the waist upwards, so as to derive no advantage from the concealment of any implements in their dress. 'The performer', says Mrs. Graham, 'took up a pinch of white sand between his finger and thumb, and scattering it gently before us, dropped it of a red, blue, or yellow colour, as we required; and, throwing up eight balls into the air, kept them in a ring at equal distances for a considerable time.' 'The small exhibitions being over, he took a round stone, as large as his head, between his heels, and, making a spring with it, he threw it to a considerable height, and caught it on his shoulder, whence, by another effort, he threw it, and caught it on his back, and so on, receiving it on his sides, the inner part of his elbow, his wrist, or his "stomach." But the most curious, though disgusting sight, was the swallowing the sword, and in this there is no deception, for I handled the weapon both before and after he performed the operation. I should have thought that this exercise would have injured him, but he is the healthiest-looking native I have seen, well made and proportioned. They begin this trade when very young, the children exercising with short bits of bamboo, which are lengthened as the throat and stomach are able to bear them'. The language spoken at Madras by the natives, is the Talinga, usually called the Malabar.

The style of living among the Europeans at Madras has more external elegance than at Bombay, but is much the same as at Calcutta. During the cold season, there are monthly assemblies, with occasional balls, all the year. Among the principal places of public resort, is the Mount-road, leading from the fort to St. Thomas' Mount, already described. It is the fashion for the ladies and gentlemen to repair, in the gayest equipages, to this road, during the cool of the evening, where they drive around the cenotaph for an hour, conversing together, or displaying their finery. 'But the greatest lounge at Madras is during the visiting hours, from nine o'clock till eleven, when the young men go from house to house, to retail the news, ask commissions to town for the ladies,' &c. 'When all the visitors who have any business are gone to their offices, another troop of idlers appear, who remain till tiffin at two o'clock, when the real dinner is eaten, and wines and strong beer from England are freely drunk.' The party then separate, and the ladies retire to rest, or to read, until five o'clock, about which time the master of the house returns from the Fort, when an excursion to the Mount-road, and dinner afterwards, conclude the occupations of the day, unless prolonged by a ball or supper-party at night.

The following table of the climates at Fort St. George, by John Chamier, Esq. was constructed from nearly four thousand observations, made in an interval of between three and four years, in a house fronting SE., and about a mile distant from the sea. It shews that the medium height of the thermometer at Madras is 80.9; the general greatest heat, 87.1; the least, 75.5; the extreme difference, 11½.

Month.	Medium.	Greatest heat.		Extreme difference.
January	75.1	79.7	69.3	10.4
February	76.6	82.0	70.6	11.4
March	80.5	85.7	74.0	11.7
April	83.2	86.7	77.7	12.6
May	84.7	92.2	78.3	13.9
June	85.9	94.3	81.7	12.6
July	84.1	91.0	79.0	12.0
August	82.9	89.2	77.8	11.4
September	82.9	89.5	78.0	11.5
October	80.9	87.3	74.0	13.0
November	77.8	83.0	72.3	10.7
December	77.1	81.3	73.0	8.3
General Medium.	80.9	87.5	75.5	11.6

In 1794, the total population of both towns was estimated at 300,000 persons; and the number is supposed to have rather increased than diminished since that period. Madras is 1030 miles travelling distance from

Calcutta; 770 from Bombay; 205 from Tanjore; 903 from Surat; 1295 from Delhi; 290 from Seringapatam. Lat. 13° 5′ north; long. 80° 25′ east. See Rennel's *Memoir of a Map of Hindostan;* Valentia's *Travels, vol. I.;* Orme's *Military Transactions in India;* Milburne's *Oriental Commerce;* F. Buchanan's *Travels in Mysore;* Mrs. Graham's *Journal of a Residence in India;* Hamilton's *East India Gazetteer;* Wathen's *Voyage to Madras.* (*q*)

MADREPORE. See VERMES.

MADRID, the metropolis of Spain, in 40° 24′ 57″ North Lat. and 3° 42′ 15″ West Long. is situated almost in the centre of the kingdom, about 100 leagues from each frontier. It stands on a few low hills, in the midst of an immense but uninteresting plain; and, as there is a regular ascent from the coast of the Mediterranean, its level above the sea is not less than 2276 feet. Its origin has been ascribed to the Greeks, and it has been considered by others as the ancient Mantua Carpetanorum; but it is first known in history only as the palace or pleasure-house of the kings of Castile; and is said to have been founded by Alphonso VI. of Leon, and I. of Castile, who reigned in the end of the eleventh century. It was sacked by the Moors in 1109, and overthrown by an earthquake about the middle of the fourteenth century, under the reign of Peter the Cruel, but was rebuilt by Henry II. the successor of that prince. As being then only the country residence of the sovereign, the increase of houses in the vicinity was regulated by the frequency and duration of the royal visits. Considerable additions were made to the growing town in time of Charles I. who made it his principal residence; and it was chosen as the seat of government by Philip II. his son, in 1563.

The city is now about two leagues in circumference, of a square form; and, when seen at a little distance, presents no appearance of a magnificent capital; as little else is seen but its numerous church-towers and spires. It contains 15 gates, 42 squares, 506 streets, 133 churches, convents, colleges, and hospitals, 65 public edifices, 17 fountains, several promenades, and 7398 houses.

The streets are well laid out, and many of them handsome, except within the ancient boundary, where they are crooked and narrow. Many of them are long, broad, and straight. One of the most remarkable, though little frequented, is the large street of St. Bernard; but that of Alcala surpasses all the rest in beauty and extent, though the houses are not equally good nor sufficiently high in proportion to the breadth of the street. The houses in general have narrow awkward entrances, close and confused apartments, and little appearance of interior cleanliness. The streets are paved with sharp stones, which renders them unpleasant to strangers; and, though there is a pavement of flat stones on each side, it is so narrow as to admit only of one person passing at a time. They are, however, extremely clean and well lighted.

Among the squares, the most worthy of notice are, the square of the palace, which is of great extent, and open on one side towards the river Manzanarez, but, excepting the front of the palace, has no handsome buildings; the Puerto del Sol, rather of a circular form, from which five of the finest streets diverge, and which is the most frequented spot in Madrid, particularly by the idlers and collectors of news; the Plaza Mayor, near the centre of the city, a long rectangular area, in which the houses, resting on piazzas supported by pillars of freestone, are built in the most exact style of uniformity, where all the public fêtes and principal commercial transactions take place; and the square of the mansion-house, which, though small, is regular, and ornamented by a singular fountain of four lions supporting a tower, with a female figure on the top, in a military habit, bearing a standard in her hand.

There are no ancient edifices in Madrid, and even few of the churches exhibit any thing remarkable in their structure, or contain any very valuable specimens of the arts. St. Jerome's church has a gate richly ornamented with Gothic sculpture, and St. John's contains several beautiful specimens of Doric architecture, with some handsome monuments. St. Isidore's presents a noble front, and contains some good paintings. The church of the Mendicant Friars, one of the largest in the city, and built in the form of a Latin cross, contains a dome painted in fresco by Colonna, and several paintings and statues. The church of the Incarnation, of the Ionic order, is one of the handsomest in Madrid; and exhibits a profusion of the finest marbles in the construction of its principal altar. The church of the Visitation, which was built at an immense expense by Ferdinand VI. and his queen Barbara, contains many valuable materials, but is generally considered as displaying no marks of good taste in their disposition. St. Isidore's chapel, or the church of St. Andrew; the Bishop of Placentia's monument, in the Bishop's chapel; the tabernacle of silver in St. Martin's; and the altars of the churches del Salvador and Descalzas Reales, are all worthy of notice. Several of the gates, particularly the Franciscan and St. Vincent's, both of the Doric order, and the modern one of Alcala, are fine structures. The principal of the other public buildings are, the quarters of the life guards, which contain stables for 600 or 700 horses; the custom-house is of great height; the post-house, which has a very imposing aspect; the state prison, a simple and beautiful structure; and the council-house, which presents a fine union of elegance and magnificence. The royal palace, situated on an eminence at one extremity of the city, and forming a square of 404 feet on every side, and containing a court 120 feet square in the centre, is strongly built, and all its apartments vaulted, without any wood in the whole fabric. The palace contains one of the finest collections of paintings in Europe (except that those of French artists are almost uniformly excluded;) and some of its apartments, particularly the king's hall, which is embellished with mirrors of extraordinary size, are ornamented in a style of great taste and beauty. This edifice is also the depository of the state jewels and regalia, among which may be mentioned the superb throne constructed for Philip II. in which are to be seen gold embroidery, massive silver, pillars of rock-crystal three feet ten inches in height, and numerous ornaments of the more precious stones. Another royal mansion, the Buon Retiro, situated at the opposite extremity of Madrid, and opening on the promenade of the Prado, has been built at different periods, and is a very irregular stateless edifice, but the interior of its apartments is ornamented by many excellent paintings by the first masters; and the building is surrounded by beautiful gardens, (of which the other palace is destitute,) in one of which is a fine equestrian statue of Philip II. in bronze, and in another a statue of Charles V. trampling upon a figure of wrath in chains. The whole of these grounds, except that they are scantily supplied with water, form a pleasing retirement; and, in fine weather, are crowded with the first company of the metropolis. There are several other promenades, but all of them situated in such a manner as to be rather too distant and difficult of access. The most frequented, and the only one within the walls, is the Prado, so much celebrated in Spanish romances, and so frequently the actual scene of political plots or private assassinations; but by the order of Charles III. it was levelled, planted, and rendered one of the finest promenades of Europe. A broad avenue, hedged with lofty trees, and two narrow alleys, the former for the use of carriages, and the latter for walking, extend from one extremity to the other, and form a kind of enclosure to a considerable part of the city.

The city is divided into eight districts, and each of these into eight wards, to each of which an alcalde or commissary of police is attached, who is annually chosen from among the inhabitants. The police consists of a high corregidor, two deputies, and eight alcaldes de corte, and a certain number of regidors for the administration of justice. The instruction of youth in Spain had been so entirely engrossed by the Jesuits, that the expulsion of the order seemed to subvert the whole system. In 1770, a new and enlarged plan of public education was established by Charles III. by which the charge of youth is committed to a certain number of secular clergy in the college of St. Isidore. In this establishment are 16 masters and professors, viz. 3 for the Latin language, 3 for Greek, Hebrew, and Arabic, two for mathematical studies, and distinct professors for rhetoric, poetry, logic, experimental philosophy, ethics, jurisprudence, and ecclesiastical discipline. Another college is appropriated exclusively to the instruction of the young nobility, in which 118 boys are educated, in 7 classes, by 21 teachers, in all the above-mentioned studies, with the addition of the French and English languages, geography, military tactics, and civil law. There have since been added a botanical and a chemical class, a college of surgery, a professor of anatomy, a school for practical medicine, and another for cosmographic engineers. There are also several public seminaries for females, besides the king's college, in which children are qualified to become musicians for the royal chapel; and a school for mechanics, in which the pupils are particularly initiated in the art of horology.

There are numerous academies in Madrid; a Spanish academy, founded by Philip V. in 1714, in imitation of the French academy, for the purpose of cultivating the purity and elegance of the Spanish language, and regulating its orthography and grammar, and of which the chief production has been the publication of a dictionary; the academy for history, instituted in 1735 by the same prince, for the elucidation of the more difficult points in Spanish history, and furnished with a library, and collections of medals, coins, and a series of charts, diplomas, and other municipal documents chronologically arranged; the academy of St. Fernando, devoted to painting, sculpture, and architecture, which owes its origin also to Philip V. and provides instruction and proposes premiums to young artists; and the Economical Society, established in 1775, for the encouragement of industry, and promotion of agriculture. There is a royal library, formed in 1712, originally containing only such books, medals, and antiquities, as had been preserved in the king's palace, but which has gradually been augmented to more than 100,000,000 printed volumes, besides a large collection of manuscripts, with the recent addition of Cardinal Arquinto's library, purchased for the king at Rome. There is also a cabinet of natural history formed by Charles III. which is chiefly furnished with the productions of Spain and Spanish America; and which, together with the library, is open to the public. The city of Madrid is situated in the diocese of Toledo, and is under the ecclesiastical jurisdiction of the grand vicar of that city. It contains 15 parishes, and 6 chapels of ease, each furnished with resident clergy; besides 20 monasteries, and 26 convents, and several oratorios and private chapels. The secular clergy amount nearly to 500, the monks, or regular clergy to nearly 1900, and the nuns to 824. There are several ecclesiastical tribunals; and a great number of hospitals and charitable institutions. The principal hospitals are, the general hospital for males, the passion hospital for females, and the hospital of Anton Martin for both sexes, which altogether frequently accommodate about 2000 sick or infirm persons. There are asylums for foundlings, for females, for orphans, for decayed gentlemen, and for destitute clergy; and a house of industry, which receives and employs the poor of all sexes and ages. There are benevolent associations for succouring the indigent and unfortunate; for assisting women in prison and houses of seclusion; for making loans to the industrious poor; for relieving the destitute sick, and persons burnt out of their houses, or lying-in women; and for maintaining poor students at universities and colleges.

The manufactures of Madrid are very unproductive, and seldom supply more articles than what are sufficient for the demands of the capital. There are manufactures, for this purpose, of hats, of stained paper, of inlaid work in stone, of tapestry, of porcelain, which last three are exclusively appropriated to the furnishing of the palace. There is a considerable manufactory of salt petre, which employs more than 4000 men, and produces nitre of superior quality. There can scarcely be said to be any commerce proper to Madrid; and the wealth of its residents, drawn from the court or the provinces, is issued for the purchase of the luxuries and necessaries of life, which are all imported from distant provinces, or foreign countries. The adjacent country is not supposed to be capable of supplying it with subsistence for ten days; but its beef and veal are sent from Arragon; pork from Estremadura; mutton from Toledo and Leon; game from the same districts, and also from Old Castile; fish from Valencia; wheat from Old Castile; oil from Arragon and New Castile; wine from La Mancha; fruits and vegetables from Arragon and Valencia; and its water, which is excellent, from the mountains of Guadarrama.

For the reception of strangers there are inns, of which only three or four can provide decent accommodation, and which are sufficiently expensive; posadas, or furnished lodgings, where the keeper of the house sells to the inmates what necessaries they want, and prepares their repasts; and houses called Mesones, in which strangers are furnished gratuitously with sorry lodgings, but must provide their own necessaries.

The environs of Madrid present no beauties, except the promenades already mentioned, and a very few country seats, the greater part of which belong to the king. The capital commands a wide flat country, dry and bleak, without foliage, verdure, or buildings; and, though there are numerous villages within the range of the prospect, the inequality of the surface prevents them from being seen to any advantage. The slow stream of the Manzanarez, adorned with handsome bridges and poplar walks, flows in the precincts of the city; and a canal, after various attempts, has been half completed between this river and the Xarama, for facilitating the conveyance of articles from the provinces.

The climate at Madrid is salubrious and bracing, the sky almost uniformly clear and serene, the air dry and pure; but sometimes rather penetrating in the winter season, and sharp, even in summer, in the shade; which degree of cold is ascribed partly to the elevated level of the city above the sea, and partly to the snow, which almost constantly covers the summits of the adjacent mountains of Guadarrama. The most prevailing winds are the north in winter, cool and dry; the south and west in summer, which bring heat and rain. The spring is mild and genial; but the summer heats, particularly in July and August, are intense. The autumn is delightful, and rather cool; and the winter dry and rigorous. Epidemics very rarely appear; but inflammatory complaints are frequent, in consequence of the variations in the temperature; and hypochondriac affections are very prevalent, which some have imputed to the ennui and envy of court attendance and intrigues. The nervous cholic, always violent, and often fatal, is one of the most formidable diseases, and rarely fails to induce a tendency to spasmodic affections, and derangement of the viscera.

The inhabitants of Madrid are not considered as possessing any appropriate character; and present rather a mixture of manners and opinions from the different provinces, which blend together in a kind of indefinable generalities. The most prominent feature is said to be that of inordinate egotism, which is thought to be the usual produce of great cities, which are the residence of a court; but candour, or, it may be, a general laxity of sentiment, is universally prevalent. The mass of the people are coarse and uncultivated in their manners; the artizans honest, but arrogant; the tradesmen upright and obliging; the mercantile men reputable and orderly; the law practitioners consequential and coldly polite, and some of the subalterns of that class grasping and oppressive; the women of the better orders gentle, affable, polished in manners, and graceful in deportment. The common people are dressed entirely in brown cloth, made of the brown wool of the country, and the same colour is very general among the higher orders; but, in other respects, the men, even to the lowest class, are dressed like the French and Germans. A great variety, however, of provincial dresses and manners is to be seen in this metropolis. The dress of the women is more closely Spanish than that of the men, consisting pretty uniformly of a black silk mantilla or veil, which ends in a crape in front, and covers the face; and a short, and generally black petticoat, adorned like the veil with fringes or vandykes, but scarcely descending below the calves of the legs. The chief amusements are the coffee-houses, which attract great crowds of idlers; the Puerto de Sol in the morning; the promenades in the evening; the theatres and opera, which are little frequented; religious processions, particularly on Corpus-Christi day; and, above all, the bull-fights, of which the whole inhabitants are passionately fond, but which have been of late in a great measure suppressed. Strangers are well received in this capital; and it is affirmed, that no city in Europe is more completely free of nationalities. The population of Madrid, including the garrison, which consists usually of about ten thousand men, is supposed to amount to about two hundred thousand. See Link's *Travels in Portugal and Spain;* Temple's *Journey in Spain;* and Laborde's *View of Spain.*

MAESTRICHT, anciently called *Trajectum ad Mosam*, or *Trajectum superius*, was formerly one of the strongest and largest towns of the Netherlands. It is situated at the confluence of the Jeker and the Maese. It has several fine streets, a market place, two collegiate and several parish churches, a handsome town-house, and a good library. The ramparts of Maestricht consist of the old enclosure, flanked with small towers and ancient bastions; but its principal defence lies in its detached bastions, in its horn work, and in a covert place, all of which are supported by a great number of mines. On the south side of the town, on the declivity of a hill towards Liege, there is a strong fort, called St. Pierre, built in 1703, and capable of holding 14,000 men. At the end of the bridge is the small town of Wyck, which is a sort of fauxbourg to Maestricht. It has a rampart about a quarter of a league in circumference, flanked with three large bastions. The two isles, one of which is above, and the other below, the bridge, are strongly fortified. There are large stone quarries near the town, with subterraneous passages of great extent, where the farmers frequently lay up hay, corn, and other articles. Population 17,963. East Long. 4° 41′ 1″, and North Lat. 50° 51′ 7″.

MAGDEBURG, *Magdeburgum Parthenopolis*, is a town of Prussia, in the circle of Lower Saxony. It is situated on the left bank of the Elbe, and is strongly fortified with a citadel, on an island formed by the river. It is well built, and there are many large and elegant houses in the cathedral square. The principal public buildings and curiosities are, the House of the Princes, the Royal House, the Arsenal, the House of the States, the Post Office, the Custom-house, the Great Warehouse near the Elbe, the House of Otho I. the Mill and the Hydraulic machine, the Orphan Hospital, the Cathedral of St. Maurice, on which the brass statue of Bishop Ernest, and the Portal, are deserving of notice; the Garrison church, built in 1016; the tomb of Guericke at St. Sebastian, the fortifications and the citadel, where the cells are still shewn that contained Baron Trenck, Doctor Bahrdt, and La Fayette.

There are here several good institutions for the instruction of youth; a college, the royal school for girls, a provincial school of arts, two commercial institutions, and a literary club. The library of the magistracy and of St. Maurice, and the cabinets of painting of M. M. Breissig, Nithack, Sucro, Diederich, and Kuhne, are deserving of notice. The principal promenades are on the Prince's rampart, the Cathedral square, the Freemason's garden, and the banks of the Elbe.

There are many manufactures in Magdeburg: They consist of woollen cloths and stuffs, silk stuffs, cotton goods, silk and worsted stockings, hats, gloves, tobacco, snuff, black soap, ribbons, muslins, and earthen ware. There are also here several potteries, tanneries, and refineries of sugar.

Magdeburg carries on a very active commerce, which consists in all kinds of grain and fruits, which are produced in the fertile dutchy of Magdeburg, in fish, in skins, and the different merchandises of Prussia, Poland, and Russia; and in various other articles.

The environs of this town are beautiful. The convent of Bergen, with its library, and its collection of pictures and objects of natural history. At the salines of Schoenebec, they prepare about 1,080,000 bushels of salt annually.

The height of Magdeburg above the level of the sea, is about 234 feet. Its population is about 32,000. East Long. 11° 38′ 59″. North Lat. 52° 8′ 4″.

MAGELLAN, Straits of. See Fuego.

MAGGIORE, Lake of, is a large and beautiful lake, situated on the confines of Switzerland and Italy. It is about 15 or 16 leagues long, from Tenero on the north, to Sesto on the south. The greatest breadth between Laveno and Fariolo, is 2½ leagues; and its height above the level of the sea is,

According to M. Pini, .	762 feet.
According to Oriani, .	646½
According to Saussure, .	636
According to Count Morozzo,	732

It is 335 feet deep near the chapel of Bardia, opposite to Locarna; 1100 feet deep between the embouchure of the Toccia and the Belgirate, and about 1800 between Isola Bella and Laveno. The temperature of its water, according to Saussure, at the depth of 335 feet, is 5° 4′ of Reaumur.

This lake is supplied by several considerable streams, such as the Tesino, the Verzasca, the Magia, the Toccia or Tosa, and the water of the little lake of Mergozzo, and hence it receives the waters from a vast amphitheatre of mountains. For a particular account of the beautiful scenery, &c. of this lake, see Eustace's *Travels in Italy*, vol. ii. p. 385; Abel's *Manuel d'un Voyageur en Suisse*, tom. iii, p. 275; and our article Borromean Islands; and Italy.

MAGI, or MAGIANS, is the name given by the Persians to their philosophers. See our articles Arabia, Persia, and particularly the article Gabres, where we have given a full account of the descendants of the *Magi*.

MAGIC LANTERN. See Optics.

MAGIC SQUARE, is the name given to a particular arrangement of a series of numbers, in consequence of which the sum of each horizontal, vertical, or diagonal row is the same. The following diagram represents one of these squares.

16	14	8	2	25
3	22	20	11	9
15	6	4	23	17
24	18	12	10	1
7	5	21	19	13

In the preceding square, the rows of the horizontal, vertical, and diagonal columns, are 65. This subject is not deserving of any serious attention. The reader will find a short history of Magic Squares in the article Arithmetic.

MAGICIAN. See Divination.

MAGINDANAO, Mindanao, or Melindenow, the most southerly of the Philippine islands, is situated between the 6th and 10th degrees of north latitude, and between 119° and 125° of east longitude. It is of an irregular but rather triangular form, about 300 miles in length, and more than 100 at its average breadth. There is no certain account of the time when this island was first visited by other nations; but it appears to have been known to the Arabians about 300 years ago, who either converted the natives, or planted Mahommedan colonies along the sea-coast. Magellan reached it on Easter day, 1521, when he took possession of the land in the name of Charles V. It was afterwards visited by the Portuguese and the Dutch, the latter of whom attempted, without success, about the year 1689, to purchase liberty to build a fort on the island. The Spaniards, at a very early period, subdued the northern coast, but have with difficulty retained this partial conquest, and are scarcely entitled to rank it among their possessions in the Philippines. The intercourse of British vessels with the country has not been frequent, and generally not very friendly. The pirates of the island made an attack upon Prince of Wales' Island, soon after its establishment in 1798; and in 1803, set sail with a fleet of 40 prows, to invade the Company's settlement at Celebes; but in both cases were defeated with great loss.

The island is well wooded, and in many places towards the coast is covered with impenetrable jungle and forests. The most prevalent trees are the teak, larch, poone, and cassia tree.

The interior contains several chains of lofty mountains, between which are extensive plains of excellent pasture-grounds, well stored with cattle. There are several deep chasms or narrow valleys in some parts of the country, through which, during the rainy season, torrents of water rush to the sea. There are several lakes of considerable extent in the middle of the island, the chief of which, called the Great Llano, is about 60 miles in circumference, and 15 or 20 in breadth. Many rivers flow into this reservoir, but only one is known to proceed from it, which falls into the sea, on the east coast, at Yligan. There is a high volcanic mountain in the south-east quarter, in the district of Kalagan, which occasionally discharges flames and sulphur; and which the natives conceive to be the residence of a divinity, to whom they sacrifice an old slave as a propitiation, when they conclude that he is displeased, which they suppose him to be when the eruptions have been long discontinued. Among the inland hills, about 30 miles up the river of Magindanao, is a saltpetre cave, of considerable extent; and from the gelatinous mud which covers its bottom, and which the natives mix with ashes, the nitre is procured by evaporating the water which had been filtered through the mixture. Talc is found in the mountains of Kalagan, and the pearl oyster is said to have been seen on the banks and sands. Gold also is procured in some of the rivers, on the north-east coast; and a Spanish governor, with 100 men, is said to have collected 180 ounces in 20 days on the Carican river.

There are no ravenous wild beasts on the island; and on this account, the wild cattle, deer, buffaloes, hogs, goats, and horses, multiply very fast. There are numbers of teal and wild duck on the lake, and the rivers are much infested by alligators. Snakes are frequent in some places; and certain kinds are said to fix themselves on the trees, from which they spring upon the unwary passenger.

The soil of the country is well watered by numerous streams, and vegetation is highly luxuriant. The most common article of cultivation is rice; but yams, sweet potatoes, cocoa-nuts, pamplenoses, mangoes, jacks, plantains, oranges, limes, and all the common tropical fruits, are very plentiful.

The island is divided into three portions, each of which is under a distinct and independent government. The first division, which is by far the largest, is ruled by a sultan, who resides at the town of Mindanao or Selangan. The second, which comprehends a large portion of the coast to the west, north, and north-east, is possessed by the Spaniards, who have planted colonies from the Philippines, which they call Bisayans. The third, which is the inland part, including also the south coast, is under the jurisdiction of a number of feudal chiefs, or rajahs, called Illano, whose savage tribes, in 1776, were estimated at 61,000. The principal Spanish settlements are, the town of Yligan, containing about 150 houses, and that of Cayagan about 400, whose inhabitants are Philippine Christians, and carry on a friendly intercourse with the Mahommedan mountaineers and the aborigines of the interior. But the chief town of the island is Magindanao, the residence of the sultan, which is situated in 7° 9′ north latitude, and 124° 40′ east longitude, about six miles up the Pelangy, (or Magindanao river) at its junction with the Melampy. The town, properly called Magindanao, is small, but communicates by means of bridges with the town of Selangan on the opposite side of the river, so as to form one town under different names. Selangan extends about a mile down the south side of the river, and is chiefly inhabited at its lowest part by Chinese settlers, who act as carpenters and distillers. The houses are built nearly 300 yards distant from each other, along the banks, and surrounded by gardens of cocoa-nuts, mango, and plantain trees, or fields of rice and sugar-cane. Besides several strong wooden castles belonging to some of the chiefs, there is a fortified palace of the sultan, about 120 feet long and 30 broad, supported by 32 strong wooden pillars, in four rows, strongly pallisaded and defended by several pieces of cannon, and a number of brass swivels. The direct territorial jurisdiction of the sultan is limited to the county in the immediate neighbourhood of the city, which is a fine well-watered plain of 40 miles; but he possesses considerable feudal authority over the adjoining chiefs, and is one of the most powerful of the Malay princes. The form of government is partly feudal and partly monarchical; and next to the sultan is his successor elect, called Rajah Moodo. The subjects of the sultan are a mixture of Mahommedans, who accompany him on his military expeditions, and of Horaforas, the aborigines of the interior, who pay heavy taxes, and are sold along with the land as a kind of serfs or slaves. The sultan's guards are generally captives and slaves from the Philippines, and on great days they are dressed in uniforms of blue cloth, turned up with red, and trimmed white buttons of tin, with Spanish grenadier caps on their heads. One of the most powerful princes, next to the sultan, is the Rajah of Boyan, who is said to have about 20,000 male Mahommedan subjects. The laws on the sea-coast are nearly the same as in other Malay states; but among the Pagan inhabitants of the interior, old customs and superstitions are the only guides.

The inhabitants, in consequence of their intercourse with the Philippines, have acquired some of the European arts. Captain Forrest found, in 1775, that the Sultan elect was able to read and write Spanish, and to perform on the violin. Their goldsmiths make fillagree, buttons, ear-rings, &c.; but, except the Philippine slaves, who may be able to mend gun locks, their blacksmiths can fabricate little beyond a common nail. They procure their culinary utensils almost wholly from China. They manufacture a kind of cloth from the fibres of the plaintain tree, in pieces about three yards in length and one broad; and the Horaforas make a strong stuff from a species of flax. The women understand plain needlework, and the better sort make a clumsy kind of embroidery. They make salt by rearing a pile of wood near the sea, and covering it with leaves of the palm trees; and by throwing salt water on it after it has been set on fire. They then put the ashes, strongly impregnated with salt, into conical baskets; and pouring on fresh water, carry the salt into a trough, which being boiled in earthen pots, becomes a lump of salt, or sometimes only a mass of crystals.

The principal imports into Magindanao are, Hindostan cloths of all sorts, handkerchiefs of different colours, dark chintzes, Surat goods, (especially pitollies and opium,) and European cutlery. The Chinese pinks import also by the way of Sooloo, kangans, beads, gongs, basins, deep brass plates and saucers, brass wire and iron. The chief exports are gold, rice, wax, cassia, rattans, tobacco, and pepper. The Mahommedans on the coast carry on also a considerable trade with the Horaforas of the interior, who bring down on rafts of bamboos, pumpkins, potatoes, rice, yams, and other vegetables, which they exchange for salt, cloth, and coarse cutlery. The currency in most parts of the country is the Chinese kangan, a piece of coarse cloth about 6 yards long and 19 inches broad, (value 2s. 6d.) thin pieces of copper strung on a cord, called Sooloo cash; dollars, 10 of which are equal to a bundle of 25 kangans, and, in purchases of greater value, such as a horse or prow, the price is estimated by so many slaves, one of whom used to be reckoned equivalent to 30 kangans, or bundles of cloth; but, in the bazar, the common currency is nothing more than rice in the husk.

The male inhabitants of Magindanao, like most of the Malays, pluck out the hair of their heads with pincers. They are slender, but rather handsomely formed; and, though not athletic, can exert considersble strength on occasions. They are very temperate, both in eating and drinking; but, like most East Indians, are extremely nice in the choice of their rice. They are cleanly in their habits; and bathe at all times of the day, at least once in every 24 hours. Their favourite amusement is cock-fighting; but they often play at foot-ball, which they strike with the foot, hand, shoulder, or knee. Their musical instruments are gongs of different sizes, but their tunes have no variety, and are sadly discordant. The dances performed by the men on festival occasions are imitations of single combat, in which the person, who exhibits in full armour, with brass helmet, lance, target, sword, and crest, without any visible opponent, goes through all the motions of a furious attack, and often working himself up to an apparent frenzy, his friends rush in and bear him away from the field. The ladies, again, standing in a row behind one another, move slowly round in a circular direction, the leader singing, and then falling into the rear, the next in succession taking up her place, and sing till all have had their turn. The females play much at draughts on a check board, with glass beads of different colours flattened on one side. The women do not appear to be kept so much in confinement as in Hindostan, but are present at public exhibitions; and often pay visits to each other, accompanied by numerous trains of female attendants. Upon drawing near the house, they set up a loud howl, uttering the sound *you*, which is answered by those within screaming out the word *we*. Those of high rank walk with great stateliness, extending in their right hand a thin piece of silk, to shade, without concealing, the face; and followed by their slaves in a long extended line, but are not noticed by the men as they pass. At the age of thirteen, the young women have their teeth filed thin, and stripped of the enamel, in order to have them stained black, which is performed with great ceremony, and among the higher classes is accompanied by a festival. The females wear loose robes, with sashes and slippers without stockings, a variety of gold ornaments, and their hair clubbed on the top of the head with crisping pins. The Magindanese resemble the Chinese in many of their customs, such as esteeming yellow the royal colour; giving their children one name during infancy, and another when they arrive at manhood. They bury the dead very expeditiously, and, in cases of evident danger, often begin making the coffin in the sick person's presence. The body is laid into the grave, and the coffin without a bottom placed over it. A shed is erected over the grave, where the widow of the deceased lives about a week.

The Horaforas are thinly scattered over the country, and frequently migrate from one place to another, to escape the oppressions of the Mahommedan chiefs. Both sexes wear a jacket, to which the women add a petticoat, and the men a cloth bound round the middle, and passed between the thighs. The men tie their hair in a singular manner, fastening it round a circular piece of wood, about six inches in diameter, and half an inch thick, laid flat on the head; but the women tie theirs behind, and plait it like the dancing girls at Madras. They wear a number of brass rings on their legs and arms, and stretch their ears almost to their shoulders by large rings and beads. Their arms are bows and arrows; and, when they can afford to purchase them, swords, lances, and targets, like their Mahommedan neighbours. These people eat hog's flesh, and are often converted by the Spanish settlers to the Christian faith. In the interior are a tribe called Bangel, who build no habitations, but live under bushes, and in hollow trees, and are little raised in their habits above the brute creation. They are said to cover their bodies with mud; and, in this way, to surprise the wild hogs in the puddles for their subsistence. But the most universal feature in the character of the inhabitants of this island is their strong inclination to piracy; which even their chiefs, though they were inclined, could not restrain. They extend their cruizes to Java, Sumatra, Borneo, and Celebes; but their grand resort is the Philippine islands. The building of vessels for these expeditions is their principal art; and their method is doubling the planks one upon another, so as never to require caulking. They then fit the timbers without so as to clasp the planks, by which mode of building the vessel is very liable to become leaky at the beam ends. A large prow measures 90 feet in length, 26 in breadth, 8½ in depth, with 40 oars, 2 rudders, and a crew of 90 men. Some of these piratical cruizers are long and narrow; being frequently 50 feet in length, and only 3 in breadth, but furnished with outriggers to enable them to carry sail. They use the tripod mast, and row with great velocity. In bad weather they throw out a wooden anchor, and by veering away a long rattan cable, keep the head to sea; or sometimes, in a great extremity, the crew jump overboard, and hold by the outriggers for hours, to ease the vessel of their weight, which is usually the chief part of the loading, as they carry no ballast, and draw little water. They have particular laws among themselves during these piratical excursions, and preserve a certain order and discipline. The owner furnishes nothing but the hull, for which he has one-third of the plunder; the masts, sails, anchors, and cables, are made by the crew, who find also their own provisions and make their own gunpowder. Previous to sailing each man burns a bit of wax candle on a heap of coral rock stones rudely piled near the river, which they assert to be the tomb of their great ancestor the Shereef, who first came from Mecca. In rowing, which, from habit, they do with great dexterity, they have always a song, which animates them in a wonderful manner, and sometimes also beat time with two brass timbrels. When the prow is large, they strike the mast, when they approach the scene of their depredations, and hide themselves among the rocks, creeks, or small islands. They detach canoes to plunder, and return home when the vessel has thus procured a sufficient cargo of slaves and spoil. They do not usually enslave persons of their own religion, except when they attack the Dutch possessions. As the Spaniards do not allow the Bisayans (or native Christians in their Philippine colonies,) to carry firearms, the principal and most gainful excursions are made at their expense.

The language of these islanders is a compound of Malay, Buggess, and Zagala, (Philippine,) with a certain proportion of the ancient Ternate or Molucca tongue; but there are a great variety of dialects among them. See Mear's *Voyage; Asiatic Researches;* Forrest's *Voyage to New Guinea.* (*q*)

MAGNA CHARTA. See ENGLAND.

MAGNESIA. See CHEMISTRY, MATERIA MEDICA, and MINERALOGY.

MAGNETISM.[*]

THE word Magnetism, in its original and particular acceptation, is employed to denote that invisible force with which certain ores of iron, called in Greek μαγνης, attract to themselves pieces of iron that are brought near them. This property is found naturally in almost all the ores of oxidulated iron; but when the laws of its action are known, we may excite it artificially in metallic iron or steel, by a particular process.

In treating this subject, it will naturally divide itself into five parts.

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[*] The Editor is indebted for this article to M. BIOT, of the Royal Academy of Sciences.

Sect. 1st will treat of the general properties of magnets, whether natural or artificial, as deduced from the phenomena which they present.

Sect. 2d will contain an experimental analysis of the forces which these properties indicate.

Sect. 3d will contain the theory of these forces, embracing their composition, their decomposition, and the calculation of their mechanical effects.

Sect. 4th will comprehend a deduction of the most convenient processes for developing magnetism artificially; a determination of the regular and constant magnetic state obtained by these processes; and the law of the decrease of the magnetic force at different distances.

Sect. 5th will contain the application of these principles to the magnetical phenomena produced by our globe; the means of observing them by the aid of the magnetic needle; the general results deduced from the observations thus made in different parts of the earth; and the theoretical consequences which they authorise relative to the interior distribution of the magnetic forces of our globe, and the changes which appear to affect it.

This last part of the subject will be fully treated in the article Variation of the Needle, both because the results which relate to it are deduced chiefly from the variations of the needle observed in different parts of the globe, and because we shall thus be able to include the new and valuable observations made during the two late polar expeditions under captains Ross and Buchan, and also those of the French expedition under captain Freycinet, into the South Sea, towards those parts of the magnetic equator where it is of the most importance to determine the variation with the greatest accuracy.

Sect. I. *General Properties of Natural and Artificial Magnets.*

The most simple method of exhibiting the power and distribution of magnetism in a piece of natural loadstone, is to roll it in the filings of iron, and afterwards to withdraw it from them. It will then be seen that a greater or less quantity of these filings will be attached to different parts of its surface. This effect is particularly sensible in two opposite points, N, S, Plate CCCLI. Fig. 1. where the filings are accumulated in the greatest abundance, standing as it were on end. These parts are called the poles of the magnet. In order to observe their properties more easily, we shall suppose that the loadstone is cut with two plane and parallel faces, A, B, Fig. 2. in a direction nearly perpendicular to that of the greatest attraction. The following phenomena will then be observed:

Each of the poles presented to the filings of iron will attract them *at a distance*, in the same manner that a stick of sealing wax, when rubbed, attracts all bodies that are presented to it. If we suspend horizontally a small needle of iron or steel, by an untwisted linen thread or fibre of silk, or any other sufficiently flexible substance, so as to be allowed to move with full liberty, each pole of the loadstone will attract it, and cause it to oscillate round its centre. This power is exerted with equal force through either conductors or non-conductors of electricity. Water, glass, paper, and flame, do not intercept its action; insulation is unnecessary, and the loadstone loses nothing of its virtue by being touched.

Of the nature of the principle which produces these phenomena, we are entirely ignorant; but, to avoid circumlocution, we shall designate it by the name of *Magnetism*, in the same way that we give the name of *Electricity* to the unknown principle of the electric phenomena, and the name of *Caloric* to the equally unknown principle of heat. It is necessary only, in order to proceed philosophically, to attribute to this unknown principle only the properties and qualities which are indicated, or rather rendered necessary, by the phenomena which it produces.

If we place the polar surface A, of one loadstone, successively in contact with the surfaces A′ and B′ of another, we shall find that it attracts one of them, B′, for example, and repels A′; and reciprocally, the polar surface B of the first loadstone attracts A′ and repels B′. The mutual tendency of the attracting faces shows itself, not only by their adherence when they touch each other, but also by the effort which they make us feel when they are about to come in contact. The repulsion is not so easily recognized in this manner; but we may render it sensible, by placing one of the loadstones on a small plate floating upon water; for, as it is then at liberty to move, if we present to it the other loadstone, it will approach to it or recede, according as it is attracted or repelled.

We see, therefore, from this experiment, that the powers exerted by the two polar surfaces of a loadstone are not similar, since the one attracts what the other repels, and *vice versa*. The most simple expression of this result, will be to distinguish two kinds of magnetism, differing, if not in their physical essence, at least in the external and apparent mode of their action. It is thus that electrical attractions and repulsions lead us to distinguish two kinds of electricity, viz. the *vitreous* and the *resinous*, which have received these names from the manner in which they are developed; and it is of importance to remark, that each of the two magnetisms resides in one of the opposite poles of a loadstone, in the same manner as each of the two electricities resides in the opposite poles of a heated tourmaline.

If we examine the crest of filings attached to the poles of a loadstone, we shall observe that their radii are composed of several parcels of filings, adhering end to end to one another. This phenomenon is particularly deserving of attention, as it informs us, that iron placed in contact with a loadstone, becomes itself magnetic, in the same manner that an insulated body becomes electric, when held in the presence of another body that is electrified.

In order to establish this property, we must take several bars of soft or malleable iron, such as is used for the fabrication of keys. After we are satisfied that none of these bars possess any perceptible magnetism, which may be known by their not attracting iron filings, we must suspend one of them, *a b*, Fig. 3. to one of the poles B of a loadstone; the lower end *b* of this bar will immediately acquire all the magnetic properties. If we now place it among iron filings, they will adhere to it, and we may even suspend to it a second bar *a′b′*, and to this a third bar *a″b″*, as is represented in Fig. 3. All these will adhere to one another, till their total weight exceeds that which the load-stone is capable of supporting. As soon as the first bar *a b* detaches itself, they will all separate and fall; and if we again try to unite them, they will be found no longer capable of supporting each other. They preserve, however, in general, some feeble remains of magnetism, which will become sensible by placing them in filings of iron, or presenting them to iron needles freely suspended. This transient communication of magnetism will still take place, even if the first bar, without touching the loadstone, is kept at a distance from it, by the interposition of a piece of card, or a plate of glass; but then the total weight, thus supported at a distance, is less than in contact; and, therefore, it follows, that the magnetic attraction decreases when the distance increases.

If, in place of soft iron, we employ bars of steel, or iron hardened by the hammer, the adherence of these bars to one another is less easily and less readily effected, but it is more durable; and the bars, when separated from the loadstone, preserve the magnetism which they have acquired, from being in contact either with one another or with the magnet. The soft iron and the steel employed in these experiments, have the same relation to one another as a rod of metal and a stick of sealing wax submitted to the influence of an electrified body. In the metal, the decomposition of the natural electricities is sudden, but the recomposition is equally so, and it operates as soon as the metal is withdrawn from the influence of the electrified body. In the wax, on the contrary, the natural electricities are separated with difficulty, but when the separation is effected, they experience the same difficulty in their reunion, and the electric state continues after the action of the electrified body has ceased.

Magnetism may be communicated to a bar of steel in a more prompt and energetic manner by two loadstones than by one, by placing its two extremities in contact at the same time with the poles by which the two loadstones attract one another. The same loadstone may thus successively render magnetic any number of bars, without losing any portion of its original virtue, from which it follows, that it communicates nothing to the bars, but only developes, by its influence, some hidden principle. In the same manner, a stick of sealing wax, when rubbed, loses nothing of its electricity by the decomposition which its influence effects at a distance in the natural electricities of other bodies.

If, after having magnetised in this way a steel bar or wire, we suspend it horizontally by an untwisted thread or fibre, or make it float on water, by placing it on a small plate of wood or cork, it will not turn indifferently to every point of space, but it will take a determinate direction, which, in Europe, is nearly north and south. We say nearly; for, in certain places or parts of the earth, the north extremity of the bar deviates from the meridian towards the west; in others towards the east; while, in others, it coincides with the meridian itself. This deviation is called the *Declination of the magnetic needle*, or the *Variation*. It is constant at the same moment in every place; and all magnetic wires thus suspended freely will take directions exactly parallel; but this common direction varies with the time, according to laws which we shall explain from observation. See VARIATION. The vertical plane in which the magnetic needle directs itself at any given place, is called the *Magnetic Meridian*, because it deviates not much, in general, from the astronomical meridian, in those parts of the globe which were at first most frequently visited: but it has since been found, that in certain parts of the earth, particularly in the polar regions, the declination of the needle becomes very considerable, and reaches even to 90°, 100°, and 110°; so that the needle then directs itself towards the true east and west, in place of turning to the north and south.

When several magnetic needles are thus freely suspended in a horizontal situation, such of their extremities as turn to the same terrestrial pole are those which, in the magnetising process, have been in contact with the same pole of the magnet, and which have consequently received a magnetism of the same kind. If these extremities are made to approach, they will mutually repel each other; while, on the contrary, if the extremities which have received magnetism of a different kind are made to approach, they will mutually attract one another. In this respect, the two kinds of magnetism have the same effects as the two kinds of electricity.

When we hold one of the poles of a loadstone at a distance from a magnetic needle suspended horizontally by its centre, the two poles of the loadstone act at once upon the needle; but the action of the nearest pole is always the strongest. The needle then turns towards the loadstone the pole which is attracted, and keeps at a distance the one which is repelled. If, after it has taken a position of equilibrium, we turn it ever so little from its place, it will return to it by a series of oscillations, in the same manner as a pendulum pushed from a vertical line will return by the influence of gravity. A motion absolutely similar to this is observed in magnetic needles freely suspended, when they are pushed ever so little out of the magnetic meridian. From this circumstance, therefore, as well as from the constant direction which it gives them, the terrestrial globe acts upon them exactly like a true magnet; whether this faculty is owing to the number of mines of iron and magnetic substances which it contains, or whether it depends upon some other cause still more general. Hence we are furnished with an excellent denomination for the two kinds of magnetism, by calling the one *boreal*, which resides in the northern part of the globe, and the other *austral*, which resides in the southern hemisphere; and therefore, in order to preserve the analogies of the attractions and repulsions, we must consider the extremities of the bars or needles which point to the north, as south poles, and the extremities of those which point to the south, as north poles.*

The preceding experiments clearly indicate the direction of the vertical plane in which the resultant of all the magnetic forces is exerted at any particular place; but it still remains for us to determine the absolute direction of this resultant in the plane itself. In order to do this, take a cylindrical needle of steel *a b*, Fig. 4, and place on the middle of its length an axis perpendicular to it. When the needle is suspended by its centre upon well-polished planes, and accurately balanced, let it be carefully magnetised. When it is again placed upon its supports, it will no longer preserve itself in a horizontal position as formerly, but one of its poles which possesses austral magnetism will incline itself to the horizon, at least in our climate; and after a few oscillations, it will settle at a determinate angle with the vertical line. This angle is called the *Magnetic inclination*, or the *Dip of the needle;* and it is different in different places. Near the terrestrial equator, there is a zone where the magnetic needle is horizontal. To the south of this zone it inclines to the surface of the earth, the extremity which possesses the boreal magnetism; and this indicates two kinds of forces, the one austral and the other boreal, which is predominant on different sides of the equator. In the article VARIATION, we shall give the laws of this phenomenon in detail, confining ourselves at present merely to the statement of the fact, that this property has been discovered by observation.*

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* The propriety of these denominations, so just and natural, was remarked by Dr. Gilbert of Colchester, in his treatise *De Magnete, magneticisque corporibus, et magno magnete tellure*, published in 1600. This work is a remarkable one, considering the epoch in which it was written. It contains a number of fine experiments, and of just and ingenious views, though mixed with metaphysical, and even astrological ideas, which mark the infancy of science. See our Life of GILBERT.

In order to measure accurately the magnetic inclination, the axis of suspension of the needle is placed on the centre of a vertical circle of copper MM, Fig. 5. whose limb, divided into degrees, moves upon a vertical axis VV, so that it may be brought into every possible azimuth. The axis VV itself is placed in the centre of another horizontal circle, divided in a similar manner, which serves to determine the direction in which we turn the first circle MM. This apparatus is called a *Dipping needle.* We shall soon explain the precautions necessary in magnetising and suspending the needle, and also in measuring its inclination; but this cannot be understood till the laws of magnetism are established.

When the direction of the resultant of the magnetic forces excited by the terrestrial globe is thus ascertained in any particular place, its action may be instantaneously exhibited by a very striking experiment. Suspend a magnetic needle *a b* by its centre, with an assemblage of untwisted fibres of silk, placing it in a small dish of paper, and balancing it by a small counterweight on the south branch, so that it may have perfect liberty to move in a horizontal plane. Now, since the needle will naturally be in the magnetic meridian, and will lie there in a state of rest, take a bar AB of soft unmagnetised iron about five feet long and four-tenths of an inch square, and, inclining it nearly in the direction of the magnetic inclination, hold its lower end A near the northern extremity of the needle, and a repulsion will immediately take place. If, on the contrary, the upper end B of the bar is held to the northern end of the needle, by making the bar descend parallel to itself, as in Fig. 7, an attraction will take place. Hence it is obvious, that in this inclined position the bar of iron is suddenly magnetised by the magnetic influence of the globe, in the same manas it would have been by the influence of any other loadstone that had been presented to it; the lowest half of the bar nearest the earth acquiring a polarity contrary to that which prevails in our hemisphere, namely, an austral polarity, and the upper half acquiring an opposite kind, namely, a boreal polarity. The two ends A, B of the bar are therefore in the same state as the two ends *a*, *b* of the needle, which were directed towards the same terrestrial poles, and it is from this cause that there is a repulsion when *a* and A are held near one another, and an attraction when *a* and B are brought together. In order to shew that these phenomena really depend on the sudden communication of magnetism to the bar, in consequence of the position in which it is held, we have only to reverse the two ends, while its inclination remains the same. In this case, the under and the upper end of the bar will produce the same phenomena that have been already described; and therefore the phenomena will be opposite to those which the same end of the bar had produced before. The magnetic poles of the bar will then be suddenly interchanged by reversion; and it is in order that this may be effected instantaneously, that we have employed a bar of soft iron, and not a bar of steel or hard iron.

The first idea of this fine experiment, and the correct notions which it presupposes respecting the terrestrial magnetism, belong to Dr. Gilbert. In the 10th and 11th chapters of the first book of his Work on the Loadstone, he shews, that if iron wires, without the magnetic virtue, are arranged either horizontally upon water, or suspended by an untwisted thread of silk, they will direct themselves in the plane of the magnetic meridian, and that the extremities of several of the wires, arranged in this manner, end to end, will mutually influence each other, even if they have not been previously magnetised by a loadstone. And in the 12th chapter of his third book, he shews, that when the wires of soft iron have thus acquired magnetical polarity, the direction of their polarity may be reversed, by the mere effect of inverting their position, directing to the south the extremity which was formerly to the north; and he adds, without any hesitation, that these effects are produced by the magnetic action of the earth itself, in precisely the same manner as they would have been produced by any other loadstone. Dr. Gilbert also attributes to this same cause the magnetism which the iron crosses of spires, and other bars of this metal, acquire, by being kept a long time in a vertical position. The terrestrial globe magnetises them also by its influence. The effect would be transient, if the iron which composes these bars was quite soft; but the hammering necessary to give them their shape, and even the action of the air, continued for a long time, communicate, particularly to the parts near the surface, a considerable degree of hardness. The magnetism in this case is not developed instantaneously; time is necessary for their excitation by the action of the globe; but, for the same reason, the magnetism is permanent when it is once developed. According to Gilbert, this remark was first made upon the bar of the weather-cock upon the church of the Augustines, at Mantua. Others attribute the first observation of this fact to Gassendi, who noticed it on the cross of the church of Aix, in Provence; but, with regard to the theory of the phenomenon, which is the important point, it seems to belong solely to Gilbert.

The directive property of the loadstone is one of the finest discoveries which man has ever made: it gives to navigators an infallible method of recognizing the direction of their track across the boundless ocean, in the midst of the darkest nights, and when fogs or tempests have entirely obscured the heavens. A magnetic needle, balanced upon a pivot, points out the fixed direction which they ought to keep; and this valuable indication conducts them as accurately as even the observation of the stars. Previous to this invention, so useful and simple, the sailor could not venture to a distance from the coast. The discovery of the compass has given him the means of launching into the ocean itself, and of seeking new regions, unknown to the most powerful nations of antiquity.

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* Gilbert attributes this discovery to Robert Norman, who appears to have published it in 1581, in a pamphlet entitled *New Attractive.* See the list of books at the end of the article.

In this case, as with most other useful inventions, we are ignorant of the person to whom society owes such an invaluable gift. We do not even know precisely what nation was the first to employ the polarity of the needle as a method to obtain a fixed direction in space. The Jesuit missionaries assure us, that they formerly found among the Chinese traces of this practice, which remount to a very high antiquity; but they supposed that it was employed merely for guiding them by land; and that they had never thought of using it at sea, a thing much more important, without doubt, but which might have been less so to a people whose navigations seem to have been always very limited. But, be this as it may, we find evident proofs of the existence and nautical use of the compass, in Europe, towards the year 1150; for it is mentioned in a very detailed and distinct manner in several works of this period, particularly in a poem composed in the old French language, by Guyot of Provins, which still exists in manuscript, in the Royal Library at Paris. The author describes the methods by which navigators guide themselves in their track; and, after having mentioned the observation of the polar star, he adds,

> "Un art font, qui mentir ne peut,
> Par la vertu de la Mariniere,
> Une pierre laide et bruniere,
> Où li fers volontiers se joint."

That is, "They have a practice which cannot fail, by the virtue of the Mariniere, an ugly and dark stone, to which iron easily joins itself." Guyot then adds, that this art consists in rubbing a needle upon the *pierre mariniere;* and then he says, that the point of this needle turns in consequence, in the direction of the polar star.

> "Quand la mer est obscure et brune,
> Quand ne voit estoile ne lune,
> Donc font à l'aiguille allumer,
> Puis ils n'ont garde d'esgarer,
> Contre l'estoile va la pointe."

That is, "When the sea is dark and gloomy, when neither the stars nor the moon are seen, then they put a candle near the needle, and they are not afraid to lose their way, for the needle points to the star."

Such are the leading phenomena of magnetic attraction and repulsion; but, before reducing them to a general theory, we must attend to some other details, which could not have been sooner introduced without interrupting the general train of our reasoning.

It was long believed that iron and steel were the only substances that could be rendered magnetic; but it has in later times been found, that nickel and cobalt enjoy the same property. After these metals have been purified by very accurate chemical means, needles may be constructed from them, which may be magnetized, and will direct themselves in the magnetic meridian very energetically, though with less force than needles made of steel; but, from the nature of the process employed in the preparation of these metals, it is impossible to suppose that their action is due to the imperceptible portion of iron which may still remain in them. We shall soon see what is the origin of the magnetism attributed by several philosophers to copper, and some other bodies.

A magnetic bar of any metal loses its virtue when it is brought to a white heat. Not only is it incapable, when in this state, of attracting iron, either when magnetic or not magnetic; but even if the iron itself is a magnet, it is no longer attracted by it, and remains insensible to its action. This fact, which was known to Gilbert, may be confirmed in a very simple manner, namely, by placing the pivot of a small compass needle in a good spirit lamp, with one or more wicks, and surrounding the whole with a cylindrical glass, for preventing any agitation from the external air. After having placed the needle horizontally upon a pivot, so that it can be shewn to be sensible to the action of a loadstone, or a magnetic bar held to it at a distance, let the lamp be lighted. The needle plunged in the flame, will soon become red; and if in this situation the magnetic bar is again presented to it, the needle will feel its influence, whether it is red, or bluish red; but when it reaches a white heat, it will become completely insensible to the presence of the magnet.

When this observation is made, remove the loadstone to a distance; and after having left the needle a short time in the flame, extinguish it, and the needle will soon cool and become obscure. But if, during this operation, it is found to be pointing in a direction not exactly perpendicular to the magnetic meridian, it will follow, that, after being cooled, it will have recovered some traces of magnetic power; and this power will be the more sensible, in proportion as the needle is less or more remote from the magnetic meridian. Hence we may conclude, that this power has been restored to it by the influence of the earth itself. We see, therefore, that in the progressive cooling of the needle, there is a particular temperature at which it becomes sensible to the magnetic action, while it preserves sufficient ductility and softness to be affected even by a very feeble force; after which, the increasing hardness produced by farther cooling renders it fit to preserve, in all imaginable positions, the developement of magnetism which is thus produced. This experiment, remarkable from its consequences, is found in Dr. Gilbert's work, (lib. iii. cap. 12.) Dr. Hook employed the same means for impressing magnetism upon bars of steel, by placing them in the direction of the magnetic meridian, at the moment when, after being suddenly heated, they were tempered in cold water; and Doctor Robison rendered the operation still more perfect, by substituting, in place of the weak action of the terrestrial globe, that of two powerful magnets, placed at the two ends of the red hot bars, at the instant when they were plunged in water. Dr. Robison informs us, that they thus acquire a considerable degree of magnetism: a result quite conformable to the theoretical notions that may be deduced from the process of magnetising bars, which will be soon explained. On this account, it may be important to try this method anew, as it may be found useful in magnetising bars of a large size.

In this manner of operating, as well as in those which we have formerly described, the magnetism is developed either by the influence of a magnet, or by that of the earth; but it appears that it may also be instantaneously excited by different mechanical means, such as by the blow of a hammer, by pressure, by twisting, and by electrical discharges. It may often happen, that these means produce their effect by disposing the substance of the iron to receive the magnetic influence from the terrestrial globe; but it is by no means proved that they have no share, at least in certain cases, in producing immediate magnetism.

Having taken, for example, a common iron wire of two or three lines in diameter, and from 10 to 15 inches long, crush it by resting one of its ends upon a plate of iron, or make it pass through an opening in a thick iron plate, and then bend and twist it in different directions till it is crushed. At the end of these changes it will be found to have acquired the magnetic virtue, as may be seen from its attracting iron filings, or from its attracting one end of a needle and repelling the other, when its twisted extremity is presented to it.

The same effect may be produced upon a rod of hard iron, by holding it in a vertical position, and striking its upper end with slight blows of a hammer. That the phenomenon may be very sensible, it is necessary that the rod be two or three feet long; and if it is afterwards reversed, and the blows repeated upon its other end, it will gradually lose the magnetism imprinted upon it, and will, by farther blows, acquire a contrary magnetism, so as to have its poles reversed. The same effect may be produced by letting it fall vertically upon a hard body. The utensils used by locksmiths are, from this cause, almost always rendered magnetic, by the repeated blows which they experience. Scissors, knives, and almost all cutting instruments, are more or less so, particularly if they have been employed in cutting iron. In order to shew their magnetic influence, we must present them to a small magnetic needle, suspended horizontally by a single fibre of the spiders web, or by an untwisted fibre of silk, hung within a glass receiver, so as to be free from any agitation in the air.* The smallest magnetic force will thus attract one extremity of the needle, and repel the other. By this means it is proved, that every piece of iron which has suffered any friction becomes magnetic, and that an electrical discharge, acting like a blow, developes magnetism in iron wires through which it is made to pass. From the same cause, lightning produces a similar effect upon the mariner's needle, and sometimes even reverses its poles. See ELECTRICITY.

From these facts we might to be led to conjecture, that the communication of magnetism consists in a particular kind of displacement effected among the particles of a bar of iron or steel. In order to determine this, M. Gay-Lussac has endeavoured to ascertain if these metals experience any change of dimensions when they become magnetic. He took a hollow tube of iron AB, Fig. 8, shut up at two ends, and to one of these ends he fitted a tube of glass extremely fine, and divided it into equal parts. He then introduced water into this apparatus till the tube of glass was partly filled; and having waited a certain time till the temperature of the liquid had become uniform, he magnetised the iron tube. The surface of the water in the small tube had not experienced any displacement, so that this change of state had not produced in the iron any appreciable change of volume.

It is equally established, by means of the most exact balances, that the iron does not suffer any sensible alteration in its weight, in consequence of being magnetised; a result which might have been anticipated, from the striking analogy which subsists between magnetic attractions and repulsions with those which are produced by the equally imponderable principle of electricity.

The degree of contact which exists among the particles of iron, steel, or nickel, has a great influence upon the facility with which they are rendered magnetic. These metals, when they are pure and perfectly ductile, do not retain their magnetism, but acquire it and lose it instantaneously. They may be made, however, to preserve it, either by mechanical means, such as pressing, twisting, or rolling them; or, as has been observed by M. Gay-Lussac, by combining them chemically with substances not magnetic, as carbon, phosphorus, arsenic, and tin. As the proportion of these substances increases, the magnetism is communicated with more difficulty, and it also lasts longer; but at last there arrives a limit, when it is no longer possible to develope it in any manner, and the combinations cease to be influenced by the magnet. Hence it is reasonable to suppose, that the magnetic phenomena ought to be modified by heat, which has such a powerful and immediate influence upon cohesion. We have already remarked, that magnetic bars lose their magnetism when heated to redness. M. Gay-Lussac has obtained the same result for nickel, and he has also found that this metal then ceases to be attracted by the magnet.

We shall now proceed to point out the influence of temper; and for this purpose we shall first explain the nature of this operation. When a bar of iron or of steel has been heated to redness, and allowed to cool slowly in the air, its particles, in approaching nearer and nearer to one another, take the distances and the positions of a stable equilibrium, to which they find themselves gradually drawn by the slow and progressive effect of their reciprocal attractions. But if we plunge the red hot bar into a fluid which cools its surface suddenly, the particles of this surface will take at first hurried arrangements, to which they are forced by this sudden change; and having thus become immoveable, they form a kind of crust, to which the molecules of the interior of the mass are also constrained to arrange themselves with rapidity, in proportion as the cooling reaches them. Hence there results a kind of crystallisation different from a stable equilibrium, as may be observed in Prince Rupert's drops, which are nothing else but tempered glass. When iron, steel, nickel, and cobalt, are submitted to this operation, it is found that these metals become more hard, less flexible, and more brittle, to a degree which is proportional to the suddenness of cooling; and therefore we might expect, what actually happens, that this change would have an influence upon their magnetic properties. These metals receive the magnetic virtue with more difficulty when they are tempered, and the developement of their magnetism is also much more durable. The difficulty of rendering them magnetic increases with the hardness of the temper; and this hardness has also an influence upon the intensity of the magnetic state which the bars may acquire. As the effect of temper depends on the difference of temperature in which the metal is suddenly placed, we must now endeavour to obtain a measure of it. There is no difficulty in finding the temperature of the liquid in which the metal is plunged, but it is difficult to determine that of the metal, which rises far above that degree of heat which the thermometer is capable of measuring. In ordinary cases, however, the colour which the metal acquires is considered as a good indication of the heat to which it has been exposed; and it is said to be tempered red-white, red, cherry-red, &c. according to the tint which it possesses at the instant before it is plunged into the cooling liquid. Although this indication is necessarily a very imperfect one, it is still almost always sufficient for magnetical experiments, in which the different degrees of temper have only a sensible influence to a certain degree of temperature. Higher degrees of heat do not at all change the intensity of the magnetism which the bars may acquire, as we shall soon prove, when we have explained the means of measuring this intensity.

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* This mode of suspension by a thread of silk, or by a system of threads of silk not twisted, was employed by Dr. Gilbert. See his work, lib. i. cap. 12, where he particularly recommends that all twisting may be avoided in combining them.

The different phenomena exhibited by the action of magnets, which we have already described, have a strong resemblance to those produced by the tourmaline, when rendered electrical by heat. The tourmaline acquires two electrical poles of a different kind, as the magnet does two magnetical poles; and the energy of the one, like the influence of the other, is at first most powerful at the poles themselves, but afterwards decreases rapidly towards the middle of the body, where there is almost always a neutral point. But as we are unfortunately not able to observe the arrangement of the electrified particles in the tourmaline, the analogy between the phenomena cannot give us any information respecting the arrangement of the particles of iron or steel when rendered magnetic. There is, however, an experiment, which, by imitating both, may suggest some useful conclusions respecting the mode of their constitution.

Let us suppose that a series of glass plates, armed with metal upon both their surfaces, are arranged parallel to one another, as shewn in Fig. 9, so that the face B_1 of the first communicates by a metallic wire with the face A_2 of the second, and also the face B_2 of this, with the face A_3 of the third, and so on to the last, whose posterior face B_n communicates with the ground. This apparatus being completed, let a communication be made between the first face A_1 and the chief conductor of a powerful electrical machine, and after having electrified the apparatus *par cascade* for some time, cut off the communication of A_1 with the conductor, and of B_n with the ground, by means of an insulating beam. It is then required to ascertain the electrical state of every part of the apparatus after a certain time.

In order to determine this, we must consider that at the moment of breaking the communication, the first face A_1 contains a certain electric charge, partly free and partly neutralised by the electricity of an opposite kind, which it has itself drawn and fixed upon the second face B_1: the same is true of the face A_2 with respect to B_2, and of A_3 with respect to B_3, and so on with the rest. Of all these quantities there is only the charge of A_1, which is foreign to the apparatus: All the rest proceed from the simple decomposition of their natural electricities; the absolute intensity of this development decreases rapidly from one element to the other, but whatever is developed upon each of the two is not sensible, those portions of free electricity only being sensible, which are all of the same kind as that which is fixed upon A_1.

If we now suppose the apparatus to be plunged in a perfectly insulating medium, it is obvious that this state of equilibrium will be permanent; but if it is surrounded with a conducting medium, such as air, it will gradually lose its electricity.

In order to ascertain how this will happen, we must recollect, that in the same state of the air, and the same form of surface, the loss of electricity is proportional to the total quantity of free electricity which resides in it. At the first instant, therefore, it will be stronger for the first face A_1 than for the second A_2, since the latter has less free electricity; and the loss will likewise be greater for A_2 than for A_3, and so on to the last face B_n, where it will be nothing, in consequence of there being no free electricity upon this face. But in consequence of these unequal losses, the opposite electricity will be developed: for the equilibrium which hitherto existed was not between the portions of free electricity on the different faces, but between their absolute charges; and since the first A_1 is weakened, it can no longer neutralise upon B_1, what it formerly neutralised: But as the same is true of the action of A_2 upon B_2, and of all the rest to the last face B_n, it follows that, since the electricity of this last face is not completely neutralised, a portion will become free, which, though at first weak, will gradually increase. For though, at the instant of its appearance, it is always exposed to the absorbing influence of the air, yet, on account of its weakness, it at first loses less than the free portions of the other faces, so that the change of equilibrium continues to operate in the same manner; the loss of free electricity diminishing more and more upon the first face, and increasing upon the last, and the intermediate elements experiencing intermediate changes.

There cannot, therefore, be any limit to these variations, but in the equality of the quantities of free electricity existing upon the two extreme faces of the apparatus, which also reduces their charge to equality. The disposition of the electricity, then, ought, in general, to be symmetrical between these faces and the centre of the system; the quantities of liberated electricity will be of a contrary nature on each side of the centre, and will gradually decrease in proportion as you approach to it, so that at the centre, it is evanescent, and we may touch with impunity the plate which occupies that position. But if we break the pile in this place, or in any other, and then insulate the fragments, it will develope by degrees at its broken extremity a certain quantity of free electricity, of a nature opposite to that of the extreme pole which is still left in contact. These conclusions, indicated by the theory, and which may be demonstrated in detail by the calculus, are also, as we have ascertained, perfectly conformable to experience.

The intimate constitution of magnets, whether natural or artificial, is perfectly analogous to that of the pile which we have described. The magnetic principles are developed and arranged in each particle of the magnetised bars, in the same manner as the two electric principles are in the consecutive metallic faces which communicate with one another; and they are confined in each particle, without the power of quitting it, in the same manner as the two natural electricities of each pair of communicating plates are confined there by the plates of glass which separate them from the surrounding pieces. The only difference consists in the mode of excitation, which in magnets is done only by influence, as the magnetising body can transmit nothing of its magnetic principle to the body which it magnetises; whereas in the electrified pile, the first metallic face A_1 charges itself with the excess of the electricity of the conductor which touches it, while the last B_n discharges into the ground a certain proportion of the opposite electricity. For this reason the analogy of the two apparatuses is not complete, unless when the contact of the air has carried off this excess of electricity introduced upon the first face A_1, and rendered free upon the last face B_n, an equal excess of opposite electricity. As this analogy is a point of leading importance, from its fixing precisely the idea which ought to be formed of the magnetic state, we shall now proceed to develope it, and establish in succession all its parts.

In doing this, we must first conceive two distinct magnetic principles, one of which repels itself while it attracts the other. These two principles exist originally in every bar of iron before it is magnetised, for there is no transfusion of magnetic principles in the communication ot magnetism, and nothing either enters into the iron or goes out of it by contact. The two principles are therefore combined together, and the one is masked by the other like the natural electricities of bodies, for which reason their action at a distance is then nothing. This action, however, becomes sensible, when they are separated by any external influence which acts unequally upon each, in the same manner as the natural electricities of bodies shew their attractive and repulsive properties when they have been separated by the influence of an electrified body. These magnetic principles exist in this manner, and are thus developed separately in each particle of iron, without any transmission of magnetism from the one particle to the other. For if a magnetic bar is broken into two or three, or any number of pieces, each of these pieces exhibits spontaneously two poles, like the fragments of a tourmaline, or the elements of an electrical pile, and the poles of opposite names are formed at the ends of the particles which were formerly in contact, in the same manner as happens in the tourmaline and in the pile. The act of separation, however, into several fragments, cannot have any influence in producing these poles; it only has the effect of displaying them, by withdrawing them from the attraction of the contiguous particles by which they were masked in the entire magnetic column, in the same manner as the contiguous electrical poles are displayed in the fragments of a tourmaline, or the elements of a pile. If we wish to confirm this synthetically, we have only to join by their extremities several small bars of steel, and magnetise them exactly as if they were one bar, either by placing the two extremities of the chain in contact with the opposite poles of the two magnets, or moving over all its length one of the poles of a single magnet. Whatever be the method employed, the series of bars will be magnetised in the same manner as a continuous bar of the same dimensions, to which magnetism has been communicated in a similar manner. If we employ, for example, short pieces of tempered steel wire, about one-twelfth of an inch diameter, and which together make a length of about 10 inches, we shall find in general that one end of the chain exerts the boreal magnetism, and the other end the austral magnetism; but if we break the chain, each piece of wire, disengaged from the influence of the other, will instantly exhibit two poles, and exert even boreal magnetism in one-half of its length, and austral magnetism in the other half. In order to perform this experiment in a convenient manner, we must place the small pieces of steel-wire in contact with one another, in a rectilineal groove cut in a piece of wood, and fix them there with wax, in order that they may not separate when they are in the act of being magnetised. If we now conceive the dimensions of these little wires diminished till they are reduced to a simple particle, we shall have an exact representation of the state of the particles of iron in magnetic bars, and we may then easily conceive how the system of all these little forces may, according to the proportions of those which follow one another, give opposite results at the two extermities of the bar, or even several results, alternately opposite in different points of its length.

When the two magnetisms have been separated, in the particles of a piece of hard iron or steel, experience proves that they re-unite with great slowness. It is necessary, therefore, that some cause opposes itself to that mutual action by which they have a tendency to unite. Whatever this cause is, we may compare it to the resistance which electricity experiences in moving along the surface, and in the interior of resinous bodies. The stronger it is, the more difficult will it be to communicate the magnetic state, and the more slow to lose it, as is the case with very hard steel. If, on the contrary, there were no resistance, the two magnetisms would separate in each particle by the smallest influence, and would re-unite as soon as that influence is withdrawn. This is the case with iron, cobalt, and nickel, when they have perfect softness. But even in this case no transmission of magnetism takes place between one particle and another. All the play of composition and decomposition passes in the interior of each particle, and between the one and the other there is an absolute impermeability. This is precisely what happens in the electric pile, formed by plates of glass, armed with metal. The decomposition and recomposition of the natural electricities are carried on with perfect facility between the metallic surfaces, which communicate and look to one another, without transmitting any thing across the insulating plates which separate them from the rest of the chain. This impermeability, which prevents the magnetisms that have become free from passing from one particle of iron to another, is also the condition which causes the attractions and repulsions reciprocally exerted between the magnetic principles themselves, to transmit themselves to the metallic particles, and put them in motion.*

The observations which have now been made, appear to give a clear and precise view of the intimate constitution of natural and artificial magnets. It therefore remains for us only to determine by experiment the nature and the quantity of free magnetism in each part of the body, and the law which each species of magnetism follows in its attractions and repulsions. This second point, which can be directly ascertained in electrical experiments, cannot be here treated in the same manner; for, as we are not able to insulate one of the two magnetisms, we are forced to study the compound phenomena which result from their co-existence in those bodies where their distribution is known.

When we study the distribution of electricity in equilibrium in conducting bodies, we see that it is subject to a single condition, viz. that all the quantities of electricity, which are free in the system, do not exercise any attractive or repulsive force upon any point in the interior of these bodies. In magnetism, it is not necessary to the equilibrium that the interior action should be nothing: It is necessary only that it be inferior to the resistance which the coercive force of the metal opposes to the separation or the re-union of the natural magnetisms. But this may take place in an infinity of ways, and even with discontinuities in the development of magnetism in the different points of the length of a bar; so that, in this general point of view, the question is absolutely indeterminate. There is one particular case, however, which deserves chiefly to be considered, because it presents the limit of all possible cases, and is at the same time the most useful of them all, viz. where the quantity of free magnetism is such that the sum of all the attractive and repulsive forces which result for each point of the bar, is precisely equal to the resistance which the coercive force opposes to the re-union of the natural magnetisms. When a bar is in this state, it is evident that it has in each of its points, the greatest quantity of free magnetism that it can admit; and hence it is said to be magnetised to saturation.

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* It is precisely in this way that the attractions and repulsions, which exert themselves between the electric principles, transmit their effects to the particles of non-conducting bodies, and put them in motion. In the case of conductors, this transmission is effected by the re-action of the electric principles against the surrounding air. See Biot's *Traité de Physique*, tom. ii.

The most simple and infallible means of magnetising to saturation, is to subject the bar of steel to such a powerful magnetic influence, that it produces instantaneously, in its particles, a more powerful decomposition of its natural magnetism, than that which can subsist in it after the sole resistance of the coercive force. For, by withdrawing it from that influence, the first limit which will present itself to the re-union of the decomposed magnetisms, will be that which constitutes the state of being magnetised to saturation.

Before we proceed to establish this principle by experiment, we must demonstrate the precise law according to which the terrestial magnet acts upon bars freely suspended; for as this action may be exerted at once, without any sensible diminution, upon all those that are presented to it, it holds out an excellent method of appreciating the intensity of the magnetism which we shall have developed.

Sect. II. *Experimental Analysis of the Magnetic Forces developed by Natural or Artificial Magnets.*

When a magnetic needle, freely suspended by its centre, is carried in succession to different places not very remote from each other, compared to the dimensions of the terrestrial globe, the directions which it assumes, in consequence of the magnetic action of this globe, are sensibly parallel; and it is only by carrying it to several places at a great distance from one another, that we begin to discover some slight deviation from this parallelism. The same result is obtained when we carry it to a height above the surface of the earth, or descend with it into deep cavities, provided always that it is kept at a distance from minerals, or bodies that have a magnetical action. This phenomenon, which is true for the smallest as well as for the largest needles, proves that the magnetic force of the terrestrial globe may, like that of gravity, be supposed to act in parallel lines, when they are compared with places at a little distance from each other. All the mechanical considerations, therefore, by which we calculate the equilibrium of heavy bodies, may be also applied to magnetic bodies, taking care that they are heavy and magnetic at the same time.

In order to examine the consequences which result from this principle, let *a b*, Fig 10, be a magnetic needle of any form, suspended by its centre of gravity C, so that it could only turn round this point. The action of gravity will be destroyed by the resistance of the point of suspension; and, therefore, we may consider the needle as destitute of weight, and as influenced only by the magnetic forces of the terrestial globe.

In order to analyse distinctly the effects which it will experience, we shall follow the same steps as in the phenomena of gravity, decomposing, in imagination, the mass of the needle into elements so small, that the magnetic state may be reckoned uniform in each, though it varies from one element to another; and then selecting at pleasure one of the elements, such as M, we shall suppose that it has a certain quantity of free austral magnetism, and determine the forces by which it is solicited. This portion will obviously be attracted by the boreal, and repelled by the austral forces of the earth. Let M B be the direction of the resultant of the first of these forces, and M A the direction of the resultant of the second, and let these lines represent the effect of each, when they act upon a certain quantity of boreal or austral magnetism, which we shall take as the unity of the magnetic mass. Then, by completing the parallelogram MARBM, we shall combine the two partial resultants into a single one M R, equivalent to their united action; and the point M may be considered as acted upon by this single repelling force, with an intensity proportional to the magnetic mass which it possesses; in the same manner as the different elements of a heavy body are acted upon by gravity in proportion to their density. In our climate, where the boreal force is predominant, the resultant MR will attract towards the earth the elements which are charged with free austral magnetism, and will repel those which are charged with the boreal magnetism. If we, therefore, designate this, in the first case, by MR, we must, in the second, represent it in a line M′R″, equal and parallel to MR, but having an opposite direction.

But since all the points of the needle are acted upon, by one or other of these forces, with an intensity proportional to their magnetic mass, it follows, that we may apply here what is demonstrated in mechanics, respecting the equilibrium of systems of an invariable form acted upon by parallel forces. The case is indeed absolutely the same as that of heavy bodies of a variable density, if they had two different weights, the one attractive for certain points, and the other repulsive for the other points. Hence we derive immediately several important consequences, which it is sufficient to announce, in order to comprehend the truth of them from analogy.

1st, All the attractive forces being each multiplied by the austral magnetic mass of the element to which they are applied, will compose a single resultant GN equal to their sum, parallel to their common direction, and passing through a certain point G of the needle, which will be, relatively to these forces, what the centre of gravity is relative to gravitation.

2d, The repulsive forces being also multiplied by the boreal magnetic mass of the elements upon which they act, will likewise compose a single resultant G′S equal to their sum, parallel to their direction, and consequently to that of the attractive forces. This resultant will also have its particular centre of application G′, whose position depending on the mode of distribution of the combined forces, ought in general to be differeut from G.

3dly, The magnetic state of the needle being produced solely by the development of its natural magnetism, without any loss or any addition, and the quantities of these magnetisms being such, that their efforts neutralize each other at each point before their separation, it follows that the same equality ought still to subsist in their sum in their magnetic state, which is only a different distribution of the same efforts. Thus, the total attractive resultant GN ought to be equal to the total repulsive resultant G′S, and their sum will be nothing, so that they cannot give to the needle any motion of translation in space. But if we draw a plane NG, G′S, which contains them, they will tend to make the needle revolve around the point C′, situated in the middle of the straight line GG′, which joins their two points of application; and they will produce this effect, at least if the straight line GG′ is not at first placed according to the same direction as in Fig. 11; for, in this case, there would be no tendency to make the needle turn from it. This, therefore, is the position which we must give to the magnetic needle round its point of suspension C, in order that it may remain in equilibrium. In this case, the vertical plane drawn parallel to the direction SN of the magnetic forces, is called the *magnetic meridian* of the place; and the straight line GG′, is called the *magnetic axis of the needle.* When this can be assimilated to a simple rectilineal wire, Fig. 12, it always coincides with the direction of its length.

4th, Since the forces GN, GS, cannot produce any motion of translation, the needle need not be protected against them, but only against the vertical effects of gravity. It will be sufficient, therefore, for this part of its equilibrium, that its centre of gravity be supported vertically; as, for example, by a vertical wire incapable of extension, whose upper end is attached to a fixed point. The verticality of this wire will in no respects be disturbed by the magnetic forces; a result which, though conformable to experience, it is difficult to verify directly. Instead of attempting this, let us suppose that the total resultant G″R″, Fig. 13, of the magnetic forces, if it is not nothing, is decomposed into two forces, one of which G″V″ is vertical, and the other G″H″ horizontal, and directed in the magnetic meridian. If the first of these is not nothing, it ought either to act in conjunction with, or in opposition to, the force of gravity, and consequently to increase or diminish the weight of the needle. But this does not happen; for the weight of the needle, measured by the nicest balances, is the same after it is magnetised as it was before it. In order to prove, now, the horizontal force, suspend to an untwisted silk wire CZ, Fig. 14, a strip of card AB, and upon one of its extremities adjust a magnetic needle *a b* perpendicular to its direction, by balancing it with a weight M on the opposite side M, so that the card may be horizontal. Let the system be then turned, so that *a b* may be exactly upon the magnetic meridian, determined by observation from another magnetic needle suspended horizontally from its centre of gravity, and it will be seen that AB remains also in equilibrio in this position. But this could not take place, if the horizontal magnetic force directed in the line *a b* had not been absolutely nothing, since otherwise it would have tended to make the lever CA turn round its point of suspension C. This force is, therefore, nothing, as well as the vertical force, and consequently the total resultant is nothing also, as had been indicated by mechanical considerations, founded on the mode in which magnetism is developed, a mode which is then established in a rigorous manner by this experiment.

Being now acquainted with the manner in which the magnetic forces are combined in acting upon a magnetic needle suspended by its centre of gravity, nothing is more easy than to devise experimental methods for determining in each point of the earth all the elements of terrestrial magnetism with the utmost precision.

For this purpose, let us conceive the attractive resultant GN, Fig. 15, and the repulsive resultant G′S, decomposed into two others, viz. one vertical GV, G′V′, and the other horizontal GH, G′H′, and directed in the magnetic meridian; and let us call V, V′ the vertical forces resulting from this composition, and H, H′ the horizontal forces.

Let us take a magnetic needle *a b*, Fig. 16, in which we shall at first suppose that the direction GG′ of its magnetic axis is known, as we shall presently see how it is to be found. Let this needle be suspended by its centre of gravity C with an assemblage of untwisted silk fibres, and let it be balanced by a small counterweight placed upon the south branch, so that the axis GG′ may be horizontal. The effects of the vertical forces V′,V′ will then be destroyed, and there will remain only the horizontal forces H′, H′, the effects of which will tend to draw the axis GG′ into the direction of the magnetic meridian, to which they are parallel, so that they will not impress upon it any motion, if it is already in that direction; but, however small be its deviation from it, it will be drawn into it by a series of oscillations, in the same manner as a pendulum, pushed from the vertical, is made to oscillate on each side of that line by the action of gravity. The only thing, therefore, is to determine this direction, where the needle, made horizontal, may remain at rest. This may be easily done, by turning it successively into different parts of space, or by observing the limits of its oscillatory motion; for the magnetic meridian is the middle of the arcs which it describes. When the oscillations of the needle are gradually diminished by the resistance of the air, it will at last settle in one direction; and by measuring the angle between that direction and that of the celestial meridian, we shall obtain the magnetic meridian and the declination of the needle for the place where the observation was made. It has already been remarked, that this declination differs in different places, and experiences even sensible variations in the same place; but this part of the subject will be treated with more propriety under the article VARIATION, as we are at present concerned only about the state of equilibrium, upon the supposition that the magnetic force is constant.

The energy with which the needle is drawn into the magnetic meridian, depends on the absolute intensity of the attractive and repulsive forces GH, G′H′, by which it is effected; but it depends also on the position of their points of application G, G′, for the magnetic axis may be compared to a lever solicited simultaneously by these two forces. If the points of application G, G′, for example, are both on the same side of the vertical axis of suspension, it is obvious that the rotatory action of the two forces will oppose one another, and the resultant action will be equal to the difference of their statical momenta, calculated in relation to this axis. On the other hand, if the points of application, G, G′, are situated on different sides of the axis of suspension, the rotatory forces will conspire, and produce an effect equal to the sum of their statical momenta. This disposition will, then, be much more advantageous for overcoming the friction, and inertia of the suspension, when the needle is supported upon pivots; and therefore we must seek the means of obtaining this distribution of magnetism. We shall soon do this; and we shall see, that, by a method called the *double touch*, the points G, G′ may be obtained at an equal distance on each side of the centre of gravity C of the needle, so that the axis GG′ may pass through this centre. The rotatory forces will then become equal, and their effects will be exactly the same as if the needle was influenced by a single force, double of the preceding, and applied to one of the two points G, G′, and on one side of the axis of suspension CO. It is obvious from this reasoning, that, in general, the points of application G, G′, as well as the directions and intensities of the horizontal directing forces H, H′, are fixed for the same needle, whatever be its position in the plane of the horizon, provided we do not alter its magnetic state, and it remains in the same place. Hence it is evident, that if we push it ever so little from the magnetic meridian, the efforts of the horizontal forces H, H′ to draw it back, will be precisely the same as in the case of the pendulum, that is, will be proportional to the sine of the angle of deviation. Let MM. Fig. 17, be the direction of the horizontal magnetic meridian, and let us suppose that the needle *a b*, previously balanced, and at rest, in this line, has been turned from it by any force into the direction PP′. Then the two horizontal directing forces GH, GH′, applied to the points G, G′, fixed in the needle, continuing to act parallel to the magnetic meridian MM, will tend to draw back the needle into this line. In order to determine the energy of their efforts, we have only to represent their total intensity by the lines GH, GH′ themselves, and then letting fall from the extremities H, H′ the perpendiculars HP, H′P′, in the direction of the needle prolonged, the rotatory forces will be represented by these perpendiculars, or by their equals GD, G′Q′, drawn from the points of application G, G′ The values of these will be respectively equal to the products obtained by multiplying GH and G′H′ by the sines of the angles PGH, P′G′H′, which measure the deviations of the needle from the magnetic meridian. If we, therefore, call this angle *a*, we shall have $GQ = H$ sin. a, and $G'Q' = H'$ sin. a, which will be equal to the preceding, since H and H′ are equal. If, besides the value of these rotatory forces, we wish to know the effort which they exert to make the needle turn, it is necessary only to compute the statical momenta of each of them in relation to the centre of rotation C, which will be done by multiplying the intensity of each by the length of the arm of the lever CG, CG′, at the extremity of which it is applied. Calling r, r' these lengths, the momenta will be Hr sin. a for the first force, and H' sin. a, or simply Hr' sin. a for the second; and the total momentum resulting from their simultaneous action, will be equal to the sum or the difference of these partial momenta, according as the forces H, H′ tend to make the needle turn in the same or in opposite directions. The first case will take place when the points of application G, G′ are situated on both sides of the centre of suspension C, as is represented in Fig. 17; and the second, when the points are situated on the same side; but, in these two suppositions, the total statical momenta will always be proportional to sin. *a* for the same needle, and there will be no difference but in the co-efficient of the proportionality.

Coulomb has verified these results by means of the torsion balance. (See TORSION.)

This apparatus is represented in Fig. 18, consisting principally of a metallic wire, generally of silver or copper, drawn into a very slender fibre, at the bottom of which is suspended a needle in a horizontal position. A divided micrometer Z, placed at the upper point of attachment, enables us to turn it through any required number of degrees. If the suspended needle were not retained by any force, it is obvious that it would obey the motion of the wire, and, after some oscillations, it would be found to have turned horizontally the exact number of degrees marked by the micrometer; but as it is drawn at the same time by the directing forces GQ, G′Q′, Fig. 17, which tend to bring it back to the magnetic meridian, it must twist the wire in order to return, and twist it to such a degree, that it opposes a resistance equal to the statical momenta of the forces GQ, G′Q′, in the position where the needle stops. If, when this equilibrium is established, we turn the wire again in the same direction as formerly, and through a different number of degrees indicated by the micrometer, the needle will again change its place, and will settle itself in a new position of equilibrium, in which the statical momenta of the rotatory forces GQ, G′Q′, will be still equal to the re-action produced by the total torsion which the wire has experienced. By repeating in this manner the experiment for several deviations of the needle, we shall have as many corresponding torsions of the wire which produce the equilibrium. But it may be demonstrated by experiment. and also by the theory of elastic re-actions, that, in general, while the wire is not over-twisted, the re-action of torsion is proportional to the arc of the torsion which it has received; therefore the observation of these arcs will afford a measure of the directing forces for different deviations of the needle from the magnetic meridian; and by the comparison of those measures, it will be easy to determine if these forces are really proportional to the sine of the deviations, as the theory of the composition of forces has indicated.

In order to do this in a convenient manner, Coulomb adapted to the lower end of the suspending wire a small stirrup, EE, Fig. 19, formed by a very light plate of copper. This stirrup serves to hold the needle; and in order that the needle may always be placed in the same position, the surface EE of the plate is covered within with a stick of sealing wax, upon which the impression of the needle is made when the wax is in a soft state. Before using this apparatus, a needle of copper, or of any other metal that is not magnetic, is placed in the stirrup, and the micrometer is turned to such a degree, that when the needle is at rest, it directs itself to the zero of the lateral scale, engraven upon the side of the glass case. When this is done, the whole apparatus is turned, till the zero and the copper needle are exactly in the direction of the magnetic meridian, previously determined by observation, and a magnetic needle is then substituted in the place of the copper one. The suspending wire is now twisted through different angles, and the deviations of the needle from the magnetic meridian are observed. The oscillations which precede the settlement of the needle have a duration proportional to its mass, compared with that of the air; but in order to stop them sooner, there is fixed under the stirrup, by a small rod of copper, a very thin vertical plate of copper, which is immersed almost entirely in a vessel full of water. The resistance of the fluid deadens the oscillations very quickly, and without preventing the needle from arriving at the degree of deviation which corresponds to the tension of the wires. It is necessary, however, to take great care that the rod VV is entirely submerged, in order to get rid of the effect of the aqueous ring which is raised round it by capillary attraction; and in order to give precision to the results, the size and elasticity of the suspending wire must be suited to the magnetic force of the needle, employing large wires for stronger needles, and reserving the very fine wires for the case, where the directing force is very feeble.

In this way, Coulomb obtained the following results with a magnetic needle 22 inches long, and a line and a half in diameter. The suspending wire was of copper.

of the size called No. 12 in commerce: It was six feet long, and weighed four grains.

Circles of Torsion given by the Micrometer.	*Angles of Deviation when the Needle comes to rest.*	*Force of Torsion in Degrees.*
0	0	0°
1	10½	349½
2	21¼	698¾
3	33	1047
4	46	1394
5	63½	1736
5½	85	1895

From these results, it appears, that the first forces of torsion are proportional to the deviation of the needle. This conclusion, indeed, is a necessary one; for, since the total directing force is proportional to the sine of the deviation, it ought in small angles to be sensibly proportional to this deviation. In order to verify this value for large angles, let us represent it in general by K sin. a, K being a constant quantity common to all azimuths; then calling A the torsion, which is in equilibrio with the directing force in the azimuth a, we shall have

$$A = K \text{ sin. } a, \text{ and consequently } K = \frac{A}{\text{sin. } a};$$

so that one of the preceding deviations will be sufficient for determining K. Hence we see, that this constant quantity expresses the force of torsion necessary for retaining the needle at 90° from the magnetic meridian.

By employing the observations of Coulomb in succession, we shall obtain the following values.

Observed Deviation of the Needle.	*Computed values of K.*
10½	1902,24
21¼	1940,37
33	1937,89
46	1922,30
63½	1927,92
85	1917,85
Mean Value of K=1917,76	

If we divide the observed torsions by this constant quantity, we shall have the sines of the angles at which the needle ought to stop in each experiment, and we may compare them with observation, as in the following table.

Observed Torsions.	*Deviations.*		*Differences between the calculated and Observed Results.*
	Observed.	*Calculated.*	
349°.50	10° 30′	10° 28′	−0° 2′
698.75	21 15	21 17	+0 2
1047.00	33 0	32 57	−0 3
1394.00	46 0	46 24	+0 24
1736.50	63 30	64 27	+0 57
1895.00	85 0	79 55	−5 5

The last of these differences, which is the only one that deserves notice, depends probably on a small alteration produced in the reaction of the wire, by the great degree of torsion to which it was necessarily subjected in the last experiment. The perfect agreement of all the other results confirms the accuracy of the law.

We have already pointed out the method of determining the magnetic direction, by observations on the magnetic needle balanced horizontally. The same object may be obtained by the aid of the dipping needle, which is shewn in Fig. 5, and of which we have already given some account. In this instrument the needle can only turn vertically round its horizontal axis, without going out of the vertical plane, where we place the circle in which it oscillates. Let us suppose, therefore, that this circle is directed perpendicularly to the magnetic meridian, and then the horizontal forces H, H′, which are parallel to this plane, will be completely destroyed by the resistance of the suspension: The vertical forces, V, V′, therefore, acting alone, will tend to turn the magnetic axis in their own direction, that is to say, to make it vertical, so that if we place it in this position, it will remain at rest. Here, then, we have a mark for recognising the direction perpendicular to the magnetic meridian: we have only to turn the vertical circle, which carries the needle till this condition is satisfied, and having read on the horizontal division where it stops, to bring it back to 90° from this point, and it will be found in the magnetic meridian.

In this new position, if we observe on the vertical circle the point of the division where the magnetic axis stops, the arc comprehended between this division and the lower vertical point of the same circle will give the *magnetic inclination*, reckoned from the vertical of the place. In order that this observation and the preceding may be exact, great care must be taken to verify the horizontality of the azimuthal circle on which the instrument rests, and which for this purpose is furnished with two levels placed at right angles to each other. If the horizontality is not perfect, it will be necessary to effect it by raising or depressing the screw which forms the foot of the instrument.

The dipping needle being directed in the magnetic meridian, and its magnetic axis being in equilibrio upon the direction of the forces which influence it, push it ever so little out of the direction of its equilibrium, without making it deviate from the same vertical plane, it is manifest that the magnetic forces will tend to bring it back to it by a series of oscillations, the laws of which will be absolutely the same as those of a pendulum oscillating by the action of gravity. Supposing then that we know the distribution of magnetism in each point of the needle, we could determine its centre of oscillation, in the same manner as we determine that of a heavy heterogeneous body; and then, observing the number of oscillations which it performs in a given time, we could compare them by calculation with those which would be performed in the same time, by a simple pendulum of the same form, and the same mass in which the magnetism, whether boreal or austral, would be replaced by terrestial gravity, taken positively on one side, and negatively on the other, which would give the ratio of the intensity of the magnetic force to that of gravity. This ratio will depend on the absolute quantity of magnetism developed in the needle and on its distribution, and therefore it will change with these two elements; but what is a very important condition, it will remain constant for the same needle, if it preserves always the same magnetic state, or if, having lost it, it is remagnetised in the same manner, and to the same degree. Hence, if we carry this needle to different parts of the earth, and count the number of oscillations which it there performs in the magnetic meridian in the same number of seconds, we may without any calculation compare the intensities of the magnetic force of the globe at these different places, in the same manner as we compare the intensities of gravity by means of the pendulum, and in both these cases, the intensities will be proportional to the square of the number of oscillations.

M. De Humboldt, for example, having carried the same dipping needle from Paris to Peru, and from Peru to Paris, found, that before and after its return, it performed at the first of these points 245 oscillations in ten minutes of time, whereas at Peru it performed only 211. The intensity of the magnetic force, therefore, at Paris, is to its intensity at Peru, as the square of 245 to that of 211; that is, as 60025 is to 44520, or as 135 is to 100. We shall soon examine the laws of these variations, confining ourselves at present to this single example.

As the method of observation which we have just explained has always some inaccuracy, owing to the friction of its suspension, we may advantageously substitute the observation of the horizontal oscillations, combined with that of the magnetic inclination. Let us conceive that we have counted the oscillations of a horizontal needle, suspended, as in Fig. 16, by an assemblage of silk fibres, which may be supposed to have no torsion, it will be easy to deduce from this the number of oscillations that the same needle will have performed round the direction of the magnetic inclination, if it had been freely suspended; for the horizontal forces H, H′, are only the total resultants GN, GS, Fig. 15, decomposed horizontally in the plane of the magnetic needle; so that, if the magnetic inclination VGN, computed from the vertical, is called i, and GN or GS are called R, we shall have H or H′ equal to R sin. i, and then $R = \frac{H}{\sin. i}$; therefore, if we observe the horizontal oscillations of the same needle at different points of the earth, and at the same time determine, by direct observation, the inclinations at each of these points, the intensities of the resultant R will be proportional to the square of the numbers of horizontal oscillations, in equal times, divided by the sine of the inclination in each place. We must take care, however, not to effect the horizontality of the needle by a counterweight, which, becoming variable in the different latitudes, would change the statical momentum of the mass to be moved. It will be sufficient to attach to the suspending wire a small horizontal dish of paper, for the purpose of receiving the needle, the rigidity of which will prevent it from inclining.

Hitherto our observations on the direction have been related to the magnetic axis of the needles. We must therefore know how to determine this axis, which is done in the following manner.

Let ABCD, Fig. 21, represent a magnetic needle, balanced in such a manner as to remain horizontal, and suspended by a wire, the prolongation of which passes through its centre of gravity c. When this needle is in equilibrio, its magnetic axis GG′ will be directed in the magnetic meridian of the place. This, however, is still not sufficient to determine it, since its trace in the needle is only ideal; but, from the properties which we have found in the centre of parallel forces, we know that, whatever position be given to the needle, this axis ought to remain fixed, and preserve invariably the same position relative to the surface by which it is bounded. Having now observed to what terrestrial object one of the sides AB is directed when it is in equilibrium, we then turn it upside down, and suspend it anew by the same point c, by making the suspending wire pass through a small hole cut on purpose. The magnetic axis GG′ will return to place itself in the direction of the magnetic meridian; but the sides of the needle having turned circularly round this axis, will not again find themselves in the same direction as before; and, what is a point of capital importance, they will deviate from the magnetic meridian as much as they did before, but in an opposite direction. This is shown in the figure, where the dotted line A′B′C′D′ represents the position of the surfaces after their reversion. If we have then observed the direction of one of the sides AB of the needle in the first position, and if we do the same in the second, the true direction of the magnetic meridian will be exactly intermediate between them. We may thus observe it and mark it on the surface of the needle, or mark the point of space to which it corresponds when prolonged.

In order to determine the true value of the magnetic inclination, we must perform a similar experiment with the dipping needle. Let us suppose, Fig. 22, that such a needle is exactly suspended by its centre of gravity, and that it dips when one of its faces is turned to the east of the magnetic meridian, then the magnetic axis GG′ will be found in the direction of the two total resultants GN, G′S, and the angle which this axis forms with the vertical, will be the inclination sought. But as the ideal line GG cannot be observed, let the instrument be turned back, so that the face of the needle, formerly turned to the east, be now turned to the west, the line GG will be invariably found in the same position. Hence, if it is not symmetrically directed in relation to any of the rectilineal sides of the needle, these will correspond to different points of the circular division, and we shall have the true inclination by taking a mean of their results. In this reasoning, we have supposed that the axis of suspension passes exactly through the centre of gravity of the needle. If this condition is not observed, the inclination deduced by the method just described will be inaccurate. We shall presently see how this error may be corrected.

The general form which artists have adopted for the needle, is that of an arrow, as shewn in Fig. 17, whether it is used to point out the dip or the variation. This form is no doubt more convenient for indicating the exact division at which the needle settles, and it has also the advantage of giving, with the same weight, a directing force perceptibly greater, as we shall shew in the article VARIATION; but this does not prevent us from performing, with these needles, the same operation of reversion which we have just described; for it is never certain that the point of application of the magnetic resultant is in the axis of the needle, that is to say, in the right line which joins its two points; and it is only by the experiment which we have described that the true direction can be determined.

In observing the inclination, there is still another precaution to be taken for the purpose of ensuring extreme accuracy. We have hitherto supposed that the needle is exactly suspended by its centre of gravity, in consequence of which we paid no attention to the action of terrestrial gravity; in practice, however, it is difficult, if not impossible, to fulfil this condition rigorously; and if it is not fulfilled, a considerable inconvenience must arise.

Since one-half of the needle has a greater tendency than the other to fall towards the earth, it must descend more than it would do by the action of terrestrial magnetism; and, according to the kind of magnetism which this half possesses, the true inclination will be increased or diminished: and there arises also an error in observing the intensity, in consequence of the oscillations being no longer performed round the directions GN, G'S, of the resultant of the magnetic force alone. This alternative, however, suggests the means of correcting the error of centering, which is the cause of it—at least when we know that this error is very small. For this purpose, we must magnetise the needle successively in two opposite directions, so as to invert its poles; and then observe the inclination which it indicates after each of these operations. If there is a small error of centering, one of the results will be too great, and the other too small; and the mean will be very nearly the true value of the inclination. The same double observation will give also the true intensity; but, for this last determination, it is necessary that the two branches of the needle are very symmetrical, and the magnetism similarly distributed after each operation. The first of these conditions depends on the artist who constructs the needle, and the second on the mode of magnetizing it. We shall presently have occasion to point out a method by which this condition will be perfectly fulfilled.

The observations which we have now made are applicable to all needles, and are independent of the manner in which the free magnetism is distributed in them. They suppose only that the magnetic state of each needle does not change in the different situations in which it is placed. Now, if we compare the intensities of the action which the same needle experiences from the terrestrial magnet according to the manner in which it is magnetised, we shall be able to appreciate the developement produced in natural magnetism, and to recognise the most advantageous processes for determining it. This will be the object of the following Section.

Sect. III. *Theory of the Magnetic Forces;—their Composition and Re-composition; and the Calculation of their Mechanical effects.*

The labours of the early experimentalists did not throw much light upon the subjects of the present section. The abstract theory of mechanical forces was not then sufficiently advanced, in order to enable them to calculate exactly the effects which magnetism produces, nor could they even unfold completely the complicated mode of their action. We shall now proceed to supply this defect, following always the light of experiment.

Of all the methods of developing the magnetic forces, the most simple is that which we have explained in the first section. It consists in bringing the extremity of a bar of steel or hard iron, $a\,b$, Fig. 23, within a short distance, or even into contact with the north or south poles of a magnet, AB. The free magnetisms in A and B, act upon the natural magnetisms of the bar of steel $a\,b$; but the pole A being nearest, its power will predominate, and the decomposition will be effected in every metallic particle of $a\,b$: The magnetism of an opposite name to A is attracted;—that of the same name is repelled, and by a series of separations of this kind, the extremity b of the bar acquires a pole of an opposite kind to A.

In order to be convinced of this, we have only to form with a steel wire a small needle $\alpha\,\beta$, about one-fourth of an inch long, and magnetise it by rubbing it several times, and in the same direction, upon the pole A. When this needle, suspended by its centre with a single fibre of silk, is brought near the pole A, one of its extremities, β, for example, will be attracted, and will turn itself towards this pole; but if the same needle is brought near the extremity b of the bar, which has been in contact with A, it will immediately whirl round. The extremity β which was attracted by A, will be repelled by b, and, on the contrary, α will be attracted. If we continue to present this needle to different points of the bar $b\,a$, beginning at the extremity b, we shall find that through a certain length $b\,c$, the magnetism is of the same kind as at b, but an opposite magnetism will immediately succeed, for the needle will turn round, and present its other pole to the bar. If the bar is short, and the magnet powerful, this new state will continue without interruption to the extremity a, and consequently the bar will have in its second half $a\,c$, a magnetism of the same nature as A, and in its first half $b\,c$ an opposite magnetism.

When the bar $a\,b$ is very long, it frequently happens, that the second state does not extend to its extremity, but only to a certain distance a', Fig. 24. Another magnetism then succeeds of an opposite kind to A, and to this there often succeeds even a fourth, which is again similar to A, so that the bar $a\,b$ possesses as many different poles in its length. The trial needle indicates these alternations by the inversions which it experiences at every change of magnetism; and the points of the bar $a\,b$, where this happens, are called consecutive points.

If we suspend a bar of this kind for the purpose of determining its directive force, it is obvious that the parts situated on the same side of the centre of suspension, which have magnetisms of an opposite kind, will also have opposite tendencies, the one to bring the extremity of the bar towards the south pole, and the other towards the north pole. The total directive force of the bar will therefore, in general, be more weak than if each of its half possessed throughout its whole length only one kind of magnetism. On this account, it is of the greatest importance not only to avoid consecutive points in the formation of compass needles, but also in every case; for a bar will never produce the effect which could be obtained from it if these alternations did not exist. Whatever, indeed, be the kind of experiment for which we employ it, the poles of an opposite name will act always at the same time, and their action will be opposed to each other in proportion to their proximity, because their distance from the points attracted or repelled will then be less different. Hence, the most favourable arrangement of magnetism is, when only one kind of magnetism exists in each half of the bar; and, therefore, this mode of separation, produced to the greatest extent, is the object which should be kept in view in all our researches.

When we have magnetised a bar $a\,b$ in the manner which we have now supposed, by putting one of its extremities b in contact with one of the poles A of a loadstone, the consecutive points will be more easily formed, if the metal of the bar is hard either by its nature or in consequence of tempering. The reason of this is evident. The action of the loadstone AB decreases with the distance, and there is always a certain point of the bar $a\,b$ where it becomes equal to the coercive force. Consequently, all the points situated beyond this limit, would not experience any decomposition in their natural magnetisms, if they were subjected solely to the influence of the loadstone AB; but the first part of the bar $a\,b$, where the magnetism is already developed, acts also upon these points, and tends to develop the opposite magnetism, and therefore the resultant of this action commencing at a shorter distance than that of the loadstone AB, there ought to be a term when it predominates, and it is then that the first alternation will be produced, and this ought to take place the nearer the point *b* that the coercive force is greater; for if it were infinite, the magnet AB would only develop magnetism in the point *b* which is in contack with its pole A. The same reasoning is applicable to the comparison of the action excited upon the rest of the bar by the first alternation *b c*, and by the second *c a*. The predominance of this over the following points, in consequence of its proximity, will be much more perceptible as the coercive force increases, and there will therefore be a greater facility in producing a third alternation *c′ b′*. From this manner of viewing the phenomena, the energy of the successive poles ought to diminish gradually in proportion as they are removed from the first extremity *b*, where the magnetism is most powerfully developed.

This result may be verified experimentally, by comparing the weights which will adhere to the different parts of the bar, or by the oscillations of the trial needle, as we shall presently explain.

The following experiment will, we trust, remove any difficulties that could appear to attach to this theory, as it shows that the same effects which we have described are produced by electricity.

Having taken a tube of polished glass, some feet long, suspend it by silk threads, and touch one of its extremities for some time with a stick of sealing wax, excited by friction. If we then examine the electrical state of the tube, we shall find that through a certain length from its touched extremity, it has the same kind of electricity as the wax. To this part there succeeds another, which possesses the opposite electricity, but in a weaker degree; and beyond this there will be found another portion, exhibiting the same electricity as the wax, but in a still more feeble manner. These alternations will continue to the other end of the tube, and will be proportioned in their number and extent to the force of the electricity which is employed. Here then we have the consecutive points of the magnet, with this difference only—that the electricity of the wax passes at first upon the glass, and extends over a certain length, because neither of these bodies resists, in an insuperable manner, the direct transmission of electricity: whereas the particles of iron are rigorously impermeable to the transmission of magnetism. For this reason, the first alternation in magnetised bars acquires always an opposite magnetism to that of the pole of the loadstone which touches it, while the first alternation of electricity is of the same nature in the glass as in the wax.

All the phenomena of the composition and decomposition of the two electricities may, in general, be reproduced by the two magnetisms, with the modifications which arise from absolute impracticability. As this comparison is of great importance in pointing out the truth of the theory, we shall now give some examples of it.

The first which we shall give is taken from the work of Dr. Gilbert. Place a loadstone or a magnetic bar AB, Fig. 25, so that the two poles A, B, are in a vertical position, and taking two small pieces of soft iron wire *a b*, *a′ b′*, of the same length, and about an inch and a half long, suspend both of them to untwisted silk fibres, S *b*, S′ *b′*, and bring them gradually near the pole A. When they are not very distant, as about the eighth of an inch, they will avoid one another as if they were mutually repelled, and the two suspended wires will diverge, as is represented in Fig. 25. The cause of this phenomenon is very simple. In proportion as each wire, *a b* for example, approaches the pole A, its natural magnetisms will be decomposed by the predominating influence of this pole; *a b* will therefore become magnetic, and acquire two poles, one of which, *b*, is of an opposite name to A, and the other of the same name. The same thing will happen to the second wire *a′ b′*. The extremities of these two wires, which are in contact, will therefore suddenly acquire magnetism of the same name, and therefore will repel one another; and this cause, favoured by their small size, and the mobility of their suspending wires, will shew itself by their divergence.

This experiment may be varied in the manner represented in Fig. 26, by placing the loadstone AB at first in a horizontal situation, by suspending the wire *a b* before this magnet, so that it may easily turn round its centre *c*, and then suspending the second wire *a′ b′* in a vertical situation, and presenting successively its lower extremity *b′* to the end *a*, and also to the end *b*. In the first place there will be a repulsion, as we have before seen, because the similar magnetisms are presented to one another; but, in the second place, there will be an attraction, because the opposite magnetisms have been presented to each other. Here, then, is an exact representation of the electric influences, with this difference only, that there is no real transmission of magnetisms into the different parts of the wire *a b*, but simply a real decomposition in each particle; a decomposition, in virtue of which one of the two kinds of magnetism becomes free in *b*, and the other in *a*, while the opposite magnetism is masked or neutralised.

Let us now take two plates of steel AB, A′B′, Fig. 27, of the same length, and very thin, like that which is used for watch springs. When both of them are magnetised in the same manner, by putting them in contact with the same pole of the same loadstone, or by rubbing them in the same direction on its surface, let it be ascertained what weight any one of them, for example AB, can support by its pole A, and then suspend from this pole a soft iron wire *b a*, whose weight is about 50 or 100 times less. When this is done, bring the second plate A′B′ slowly towards the first, or if you wish to place the one upon the other, with their opposite poles coincident, and when they come in contact, the adherence of the wire *b a* will be almost entirely destroyed; so that the system of two magnets thus combined can only support an infinitely small portion of the weight, which each of them would have supported separately.

We have supposed the two plates to be very thin, in order that their distance at different points from the wire *a b* may be almost equal when they are placed upon one another. In the second plate A′ B′ indeed, this distance is unavoidably greater by the whole thickness of the first AB; and it is from this cause that the actions of the two equal plates are not exactly destroyed. This inequality of action, however, though it cannot be removed, may be diminished by diminishing the thickness of the plates; or the same effect may be produced, by taking a second plate A′ B′ more powerful than AB. The wire *a b* will then fall of its own accord, when the action of the plate A′ B′, diminished by the excess of distance, becomes equal to the action of AB, which will happen either at the instant of the contact of the two plates, or before it.

In this last case, if the distance of the two plates is farther diminished, the action of the second will finish by preponderating, and the wire *a b* will return again to attach itself to the pole A, but with a magnetism opposite to that which it had at first. It is easy to vary these phenomena; but the two experiments which we have described are sufficient for indicating the explanation of all others that may be devised.

There is an electrical experiment, suggested, we believe, by Æpinus, which has a great analogy with the preceding. Take two disks of thin mirror glass, AB, A′B′, Fig. 28, whose surfaces are very plain, which have a diameter of about four inches. Fix to each of them a handle CM, C′M′, either of glass, sealing wax, or any insulating substance; and, having fitted up a pendulum *s a*, formed with a small ball of the pith of elder-tree, suspended to a silk fibre, rub the disks against one another, holding them by the insulating handles, and, without separating them, present them at the same instant to the pendulum. It will then be seen that they do not exert upon it any attraction when thus combined; but the moment they are separated and presented in succession, they will both attract the pith ball. The two plates, therefore, have been mutually electrified by the friction, and one of them has acquired the vitreous and the other the resinous electricity, as may be ascertained by presenting them successively to a second pendulum charged with a kind of electricity which is known. The electricities of the disks do not shew themselves when they are in contact; for since they reside in the two touching surfaces, the distance of all their points from the pendulum is absolutely equal for them both; and then the opposite actions which they exercise in order to separate the combined electricities of the pith ball being equal, the total resulting force must be nothing. We may even modify the experiment, so that this compensation may be progressive: For this purpose, after having separated the disks, present the rubbed surface of one of them to the small pendulum, and allow it to approach till they come in contact; as soon as it has taken upon its surface the very small quantity of electricity corresponding to its volume, it will be repelled from the disk. Let it then be held in this state of repulsion, by presenting to it the other face of the disk, as is shewn in Fig. 28; for the electricity will still act upon it as well through the thickness of the glass, and then bring near by degrees the second disk to the first, as if for the purpose of bringing back into contact their electrified faces. In proportion as the distance of these faces diminishes, you will observe the repulsion diminish, and the pendulum will descend more and more to a vertical line; and when they at last touch one another, the system of the two disks will have no more action upon the small pendulum than any other piece of glass in its natural state; but we may make it ascend anew, by again separating the disks. The two electricities thus neutralised by their contact, represent the two combined electricities in their natural state, with this difference only, that the latter in conducting bodies are united only by their force of combination, and may be separated by the action, at a distance, of electricity, become free; whereas, in our disks, each of them is retained by the resistance of the nonconducting power of the glass opposed to the liberty of its motion.

For this reason, the experiment which we have described will succeed equally well with disks of gumlac or sealing wax, or even with one disk of these substances, and another made of metal; but it cannot be performed with two disks that are both metallic, or that are formed in general of conductors; for as in these cases there is no resistance opposed to the motion of the electricities, which are disengaged by friction, they will reunite in proportion as the friction disengages them. The analogy between this experiment and the one which we have described, as made with two magnetic plates, Fig. 27, is complete, and we may apply to the two magnetisms in the case of the plates, every thing that we have here said of the two electricities.

We have already remarked, that a loadstone loses nothing by magnetising any number of bars; but, what we could not then have foreseen, the effect of these repeated operations, instead of diminishing, rather increases its energy. When the pole B, Fig. 29, of a loadstone touches the extremity *a* of a bar, and developes in it a magnetism, contrary to that which it possesses, this magnetism, in its turn, acts upon the natural magnetism of the loadstone which produces it, and tends to excite in it a new decomposition, which augments the free magnetism of B. This augmentation produces in the bar *a b* a new decomposition, which again reacts upon the pole B, so that both of them, by this mutual re-action, acquire a more intense degree of magnetism than they would have done by the direct action of B. This is quite analogous to the increase of charge which the upper plate of an electrical condenser receives from the action of the electricity which is masked in the lower plate; but the electric equilibrium establishes itself instantaneously in the plates, because they are composed of materials capable of transmitting electricity with extreme facility; whereas the maximum charge of a loadstone, and of bars which touch it, is produced slowly. For, on the one hand, if these bars are made of steel or hard iron, the coercive force opposes itself to a ready decomposition of their natural magnetisms; and on the other hand, the substance of the loadstone opposes to the increase of its magnetism a similar resistance. The first of these obstacles may be destroyed, by making the bars of very soft iron, but the second is unavoidable; and it follows from this, that it must require a good deal of time, till the system may develop all the magnetism which it can acquire.

This remark explains several important phenomena. If we suspend to a natural or artificial loadstone all the quantity of iron which they can support, and if we leave the iron suspended, it will be found that we can increase it by a very small quantity every day; but if, at the end of some weeks, or even months, we forcibly detach all the iron, and try again to replace it, we shall find that the loadstone is no longer capable of supporting it. It will lose instantly all the excess of force which it had acquired by the influence of the iron. Indeed, under this influence, the two magnetisms, partly neutralized by those of the iron, could exist in a state of decomposition which the coercive force is no longer able to maintain; the loadstone, therefore, abandoned to itself, ought therefore to return to the maximum of magnetic force which the nature of its substance permits it to have, that is, to its state of saturation.

This result has been very advantageously employed for increasing the force of natural or artificial magnets, by fitting them up with what is called *armour*. This armour consists of pieces of very soft iron, applied to the polar faces of the loadstone, and which, becoming themselves magnetic by influence, increase its energy every day. Let us consider a loadstone of a square form, such as AABB, Fig. 30, having AA for its north, and BB for its south pole. Let us now suppose at first, that we apply to the first of these poles an armour of soft iron A′ A″ A‴, of the form indicated by the figure, the natural magnetisms of this plate will be soon decomposed; its boreal magnetism will be attracted by the austral magnetism which prevails in AA, and its austral magnetism will be repelled, so that this last will predominate over all the exterior surface A′A″A″ of the plate of iron, but principally in the most distant extremity A′A″, which is called the foot of the armour. Let us now envelop with a similar armour the other pole of the loadstone BB; a similar decomposition will be produced, and the foot B′B″ will acquire boreal magnetism. At the end of some time, the influence of the armour will have produced a perceptible decomposition of magnetism in the particles of the loadstone which it envelops, and this will be considerably stronger. It is not convenient that this envelope be too thin; for, all circumstances remaining the same, the development of magnetism which can be produced in a piece of iron depends upon its mass, and it is not convenient also that it be too thick, as the greatest energy of their action does not reside upon their lateral surface, but in their feet A′A″ B′B″. The advantages of this circumstance we shall soon have occasion to explain. Generally, the proper thickness of the armour of each magnet must be found from experience. It is is always evident that this armour ought to be made of soft iron, in order to facilitate the decomposition of magnetism. Steel and hard iron would be injurious for this purpose, though they have been recommended by some writers.

The arming of magnets not only increases their force by a new disengagement of the magnetism which it excites, but it increases it also by giving a better direction to the magnetic forces. Let us suppose, for example, that we wish to make use of the loadstone AABB for magnetising the bar *a b*, Fig. 31, by presenting one of its extremities to the northern face BB. It is manifest, from an inspection of the figure, that the greatest number of points of this face, as well as the points beyond them, will act very obliquely upon the bar, and will consequently have little influence in decomposing by their attraction the magnetism of its particles in the direction of its length *a b*. Besides, the austral surface AA, which is parallel to the first, will oppose this effect by its contrary influence; and though its action is more feeble, because it is exerted at a greater distance, yet it has the advantage of a more favourable direction, from its acting at less angles with the length of the bar. On the contrary, when the opposite energy of each pole is turned aside, and carried in a great measure into each foot of the armour, let the bar *a b* be held in the prolongation of one of the feet, as is represented in Fig. 32, we shall first perceive, that the action of this pole, concentrated as it is, in the foot, will act much more directly in the direction of the length of the bar, than the large surface of the magnet BB did, as shewn in Fig. 31; and, on the contrary, the action of the other pole, carried into the corresponding foot, will act much more obliquely on the bar than it did in the case of parallelism; the latter will therefore have much less influence in opposing the immediate action of the foot to which the bar is applied. By these means, we are able to communicate to a bar a much higher degree of magnetism than could have been done with the same magnet unarmed; or, what is the same thing, we can support by an armed magnet a bar of soft iron of much greater weight than could be supported without the armour. In order to preserve a magnet of this kind, we must apply to its two poles a parallelopiped of soft iron *a′ b′*, Fig. 33, which answers for the purpose of an armour, and which is taken away when we mean to employ the power of one of its poles. The preserving influence of this parallelopiped is founded upon the same principle as the use of the armour.

If we rub, in the same direction, bars of steel or hard iron upon the poles of a loadstone, prepared in the preceding manner, we shall obtain the highest degree of magnetism which can be obtained by simple contact; but the necessity of giving to compass needles the highest possible energy has given rise to various methods, which we shall proceed to describe in the following chapter, pointing out their respective values by means of the principles which we have already established.

SECT. IV.—*Deduction of the most convenient Methods of developing Magnetism artificially—Determination of the regular Magnetic State obtained by these Methods—Law of the Decrease of the Magnetic Force, with the Distance—Conjectures respecting the Nature of the Magnetic Principles.*

In the first method of making artificial magnets, which was for a long time almost the only one in use, the plate or bar of steel was rubbed at right angles upon one of the poles of either a natural or artificial magnet. In order to estimate the effect of this method, let us first consider the bar *a b*, (Plate CCCLII.) Fig. 34, when its extremity, *b*, begins to be applied on the pole, A, of the loadstone AB, and let us suppose that A is the south pole of this loadstone. In this case, the austral action of the part CA, predominating over the boreal action of the portion CB, it will produce in B a decomposition of the natural magnetisms of the plate; the austral magnetisms of each particle will be repelled towards *a*; the boreal magnetism will be attracted towards *b*, and it will form in *b* a north pole. But when the pole A quits the extremity *b*, and begins to rub upon the succeeding points *a b*, it will produce upon each of them the very same effect; that is, it will attract the boreal magnetism of each particle to the actual point of contact, and will repel from it the austral magnetism. But the continuance of this repulsion will at last be found to have destroyed entirely the first decomposition of magnetism which it had at first excited by immediate contact in the extremity *b*. In proportion as it advances on the plate, the pole will continue to produce the same effect, and to destroy successively, by its influence at a distance, the decomposition which it produced by contact upon the points which it had previously touched. At the last extremity, however, this destruction no longer takes place; and, consequently, when it quits it, it ought to leave it in a state of boreal magnetism, as is represented in Fig. 35, where the last position and the definitive state of the plate are represented by *a′ b′*. Hence it is nearly to this last effect that the action of the present method is limited; and, consequently, we should not expect more success than from the method of simple contact which we had first employed. This result may be confirmed by experiment: for if we measure by means of the torsion balance the directive forces obtained by this method, and compare them with those given by the other methods which we are about to describe, we shall find that it is not capable of magnetising to saturation any needles but those whose thickness is very small.

This method has also the disadvantage of producing consecutive points frequently and easily, like the method of simple contact, particularly if the plate of steel is long and hard, and if the magnet is kept longer on one point than another. This last circumstance is sufficient of itself to produce these points; for if we take a plate of steel that has been regularly magnetised, that is, which has each of its halves of the same kind of magnetism, and apply one of the poles of a needle to several parts of its length, a pole will be created in these points of an opposite name to that of the pole of the magnet which is applied; at least, if the magnet is more powerful than the plate. If the magnet is very powerful, and the plate not thick, it is sufficient to apply it to the middle of its length, in order to create in this point a pole, and two opposite poles at the two extremities, as may be verified by the trial needle $\alpha\,\beta$, which we have already employed, as in Fig. 23, to discover the nature and the inversions of free magnetism.

The method of making artificial magnets which we have described presents a remarkable phenomenon. When the plate *a b*, Fig. 34 and 35, has been thus rubbed upon one of the poles of a very strong magnet, on the south pole for example, and has consequently received a high degree of magnetism, let it be rubbed along its whole length, and in the same direction upon the homologous pole of a weak magnet. We should then be led to believe that this operation, performed in the same direction as the first, would augment its magnetic state, or, at any rate, would leave it as it was before; but it is actually diminished, and the magnetism is reduced to the same intensity as if the plate had been magnetised by the weak magnet. In order to understand this phenomenon, we must consider, that the second magnet, in touching successively every point of the first half of the plate, creates for a moment, by its contact, a magnetism opposite to that which the first magnet had left in it; at least, if we suppose that the second magnet is formed of iron sufficiently hard to prevent its own magnetism from being destroyed by that of the plate. This local inversion is produced constantly, though the second magnet is weaker than the first, because it acts successively on each point by immediate contact, whereas the first magnet produced the final state of magnetism by acting at a distance. In proportion, therefore, as the second magnet rubs upon the first half of the plate, by touching it with its south pole, each point which it touches is, at first, brought back to its natural state, and then passes to the boreal state, and receives afterwards, by an influence at a distance, the final degree of boreal or austral magnetism which the magnet can give it, by combining its action with that magnetism of which it had already been rendered free. But, as these successive changes of free magnetism cannot take place in the one half, without creating corresponding changes in the other, it is obvious that the plate, after having experienced this disturbing force over the whole of its length, will be brought back precisely to the same degree of magnetism as if it had been touched only by the second magnet. It is manifest, also, that this reduction will not take place if the north pole of the second magnet touches the plate only on its south half; for then the magnetism of the latter will be rather augmented than diminished. For the same reason, there will be no longer any diminution, if the magnetism of the plate was sufficiently strong to destroy that of the second magnet and reverse its poles. The extreme case of this supposition will happen when this magnet is made of very soft iron, in which the decomposition and recomposition of the natural magnetisms may take place with extreme facility; for then, as this iron passes over the different points of the plate, it will acquire, at the moment of contact, a magnetism opposite to that of the point which touches it, and consequently, by its reaction, it will tend to augment the species of magnetism which this point already possessed. This would be, as it were, a moveable armour, applied in turn to different points of the plate; and we think there can be no doubt that this repeated friction, instead of diminishing the magnetism of the plate, would soon bring it to its maximum.

After many fruitless attempts to modify and bring to perfection the method of making artificial magnets by simple contact, the first step towards more complicated and better methods, was made in 1745 by Dr. Gowan Knight, of London. Having joined by their ends two bars strongly magnetised, the north pole of the one touching the south pole of the other, he then placed upon these bars, and in the direction of their length, a small bar of steel, tempered at a cherry-red heat; the middle of which corresponded with the point of junction of the two large bars, and separating the bars, he made each of them rub upon its corresponding extremity of the small bar, which was found to acquire by this operation a more intense degree of magnetism than had hitherto been obtained.

In this process, each magnet acts upon the half of the small bar which it passes over, as in the first method; but, in that case, the influence of the same magnet acted alone over all the length of the plate, in order to develope the two magnetisms; whereas, in the new method, this decomposition is favoured by the presence of the other magnet; for, in all the points which lie between them, their influence is combined, and the kind of magnetism which is attracted by the one towards one extremity of the bar, is at the same time repelled by the other towards the same extremity. By employing this method, and making use of large bars strongly magnetised, it is found that small bars, when they are short, and not very thick, acquire nearly a maximum of magnetism; but it is impossible by this process to magnetise a long bar to saturation. Dr. Knight invented also a particular kind of ferruginous paste, with which he constructed bars susceptible of a very high degree of magnetism. We shall have occasion to speak of it at greater length, when we come to determine the substance and the preparations which are most suitable for this purpose.

The small bars of Dr. Knight, which were found in every physical cabinet, induced at this period several philosophers to seek other means of obtaining the same degree of magnetism in larger bars. M. Du Hamel, of the Academy of Sciences, having united himself with Antheaume in this research, contrived the following method: Having placed parallel to one another two bars of steel of the same length, AB, A′B′, Fig. 36, he united their extremities by a small parallelopiped FF′ of very soft iron, so as to form a right angled parallelogram. He then took two bundles of bars *a b*, *a′ b′*, previously magnetised, and united their poles of different names towards the middle of one of the bars of steel, after which, inclining the bundles as is represented in the figure, he made them pass towards each extremity of the bar; and by a successive repetition of this friction upon each bar of steel AB, A′B′, he obtained a considerable degree of magnetism. In this arrangement, each bundle acts upon the half of the bar, which it runs over as in the first method. The employment of two bundles instead of one has also the same advantage as the method of Dr. Knight; but the application of two small bars of soft iron to the extremities of the bars of steel is a very important addition; for as soon as the bars of steel have acquired any degree of magnetism, these small bars of soft iron, magnetised also by influence, will themselves act upon the steel bars like real armours; they will fix in each of their extremities the magnetism already developed, they will neutralize it, and thus give to the moving bundles a greater degree of facility in effecting a new decomposition of the magnetism by a new friction. There was now only one step to take, in order to give this method all the degree of perfection of which it was susceptible: It was necessary only to substitute in place of the small bars of soft iron two strong magnets, with their poles opposite to one another, in order to retain and neutralise still more strongly the magnetism previously decomposed by the rubbing bundles. This improvement, as we shall presently see, was made by Æpinus. But when large magnets cannot be obtained, the method of Du Hamel is the best which can be employed for magnetising compass needles, and plates which are not more than one-eighth of an inch thick, provided that the moving bundles are strongly magnetised.

About the same time that M. Du Hamel was occupied with these researches at Paris, Mr. Michel and Mr. Canton pursed the same object in England.

Mr. Michel employed two bundles of bars AB, A′B′, Fig. 37, strongly magnetised, and parallel to one another, the poles of different names being united at each extremity, in such a manner, however, that there remained an interval between them of about one-third of an inch. He then placed in the same straight line several equal bars $a\,b$, $a'b'$, $a''b''$, &c. which he wished to magnetise, and then he caused to pass over these bars at right angles, and in the direction of the line formed by them, one of the extremities of the double bundle. By this method, he found that the intermediate bars in the chain $a''b''$, $a'''b'''$, acquired a great magnetic force. The magnetism, however, which is thus obtained, never rises to the maximum of saturation.

The different bars $a''b''$, $a'''b'''$, placed in contact by their extremities, have here the same effect as the small bars of iron employed by Du Hamel. They perform the part of a real armour; but as the nature of their substance does not permit the free development of magnetism, they do not become magnetic, and they do not act till they have been touched by the moving bundles. Hence we perceive why the intermediate bars in the series are the only ones that are strongly magnetised, for they are the only ones which are armed. In this respect the method of Michel returns to that of Du Hamel, and is perhaps inferior to it; but it presents another modification which deserves to be examined, viz. the employment of two parallel bundles kept at a constant distance by their opposite poles, and rubbing simultaneously over the whole extent of the bars. In order to conceive distinctly the effect of this arrangement, let us represent the two bundles by AB, B″ A″, Fig. 38, let us suppose that the poles pass over the bar of steel $\alpha\,\beta$, and let us analyse their action upon the points, either within or without the interval which they comprehend.

We shall first consider the bundle AB, which we shall suppose not to have any consecutive points, so that the half CB, which is the most distant from the bar, possesses the boreal magnetism, and the nearest half CA the austral magnetism. If m is any particle of the bar, all the points of the bundle AB will exert upon the natural magnetisms of this particle a boreal or austral action, and will tend to separate them according to the nature of the action. But if the two halves of this bundle possess nearly an equal degree of magnetism, as they ought to do, since we suppose that the point of indifference falls nearly in the middle of its length, it is evident that the austral actions ought to predominate over the other, because the points which exert it are nearer to the particle m, so that the final and total action of the bundle AB will have for its resultant an austral force, directed according to a certain line $o\,m$, which will cut AB in the austral portion, at a little distance from its extremity: For in the magnets that have no consecutive points, the quantity of free magnetism is the greatest possible at the extremities themselves, and thence decreases towards the centre with extreme rapidity, like the free electricity in the tourmaline, and in insulated electrical piles.

Now, if we consider the action of the other bundle A′B′ upon the same particle, we shall see in like manner that there will result from it a single boreal force, whose direction, represented by $m\,o'$, will cut this bundle in its northern half at a little distance from its extremity.

In order to find the joint effect of these two forces in the direction of the bar's length $\alpha\,\beta$, we must decompose them in that direction. If we represent them by $m\,r$, $m\,r'$, each of them will give a force $m\,f$, $m\,f'$, perpendicular to the direction of the bar, and a boreal or an austral force $m\,s$, $m\,n$, in the direction of its length. These last forces are the only ones with which we are concerned, as they alone determine the longitudinal decomposition of the magnetism. But it will be seen, from a bare inspection of the figure, that if the particle m is situated between the bundles, the two forces of which we have spoken unite in decomposing the natural magnetisms, and each of them tends to carry its austral magnetism towards the extremity a. It is likewise evident, that this effect will take place upon all the other parts of the bar to which the two bundles may be carried. If the particle, on the contrary, is situated without the interval comprehended between the bundle, for example at m', the longitudinal actions of the bundles will oppose each other, and the action of the nearest one, A″B″ for example, will predominate, in consequence of its proximity, and there will result a decomposition of magnetism in $\alpha\,\beta$, opposite also to the state of the magnetism in the bar. This decomposition, however, produced by the difference of the forces, will always be weaker than the first, which is produced by their sum; and this will be particularly the case, if the rubbing bundles are placed at a little distance from each other; for their opposite influence will then become almost equal upon the points of the bar which are ever so little distant from them. The feeble development of magnetism which thus takes place in m', cannot resist the combined action of the two bundles when they are carried to m', and when that point is comprehended between them; and reciprocally, when they leave the point m', they cannot destroy in it all the development of magnetism which they at first produced when they exerted upon it their united influence. When these operations are frequently repeated from one end of the bar to the other, they will always tend to excite an increasing development of magnetism; and experience proves that this development becomes very considerable. In order that it may be equal in the two halves of the bar, the united bundles must be first applied at its centre, and an equal number of similar frictions must be made upon each half of the bar. The bundles being then brought back to the centre, they must be lifted up vertically, so as not to disturb the lateral effect which has been previously produced. This method, called by its inventor the *Method of Double Touch*, has obtained a great degree of celebrity.

Mr. Canton published a modification of this method; but it had only the appearance of being new. He formed at first, as Du Hamel did, a right angled parallelogram, by uniting the extremities of the two steel bars with pieces of soft iron; he then touched these bars with two parallel bundles, united according to the method of Michel, and then separating these bundles, and inclining them on both sides upon the bar, he made them move on both sides towards the extremities, But from what we have already said on the effect of repeated frictions with magnets of unequal strength, it is obvious that the last operation, with the inclined plates, is the only one which determines the final magnetic state of the bar; for it gives more magnetism than the other, as we shall see. The preceding modification, therefore, of the method of touble touch is quite useless, and the operation, deprived of this superfluous addition, is the identical method of Du Hamel.

Æpinus made upon the method of double touch a modification much more happy, and better contrived. He allowed the poles and the two bundles to move at a small distance from one another without even separating them, but he inclined the bundles in an opposite direction, as Du Hamel had done, and as is represented in Fig. 39. By this means, the resultant of their actions upon each particle *m* became more oblique upon the surface of the bar, and consequently the part of this resultant which decomposed itself in the longitudinal direction became more considerable. It is true, indeed, that the proper action of each point of the bundle was at the same time diminished, because its distance from the particle *m* had increased; so that the inclination ought not to be increased indefinitely. Experiment alone is capable of indicating the most favourable limit. Æpinus decided upon an inclination of 15 or 20 degrees to the surface of the bar, and this seems to be the most advantageous, though, from the nature of a maximum, any small variation in the angle will not perceptibly alter the result. Æpinus added to this modification the employment of armour, but he advantageously substituted, in place of the soft iron of Du Hamel, two strong magnets, with their opposite poles united, as we have already stated. The combination of these two operations constitutes the method to which his name has been given. In examining the results which it produces, it has been found superior to every other method, when we wish to magnetise very large bars with bundles of plates that have a feeble magnetism; but it is necessarily attended with some inconveniences, which it is of importance to notice. The first of these is, that it never produces a development of magnetism perfectly equal in the bars to which it is applied. If we place these magnetised bars indeed horizontally, under a sheet of paper covered with very fine iron filings, we shall see, from the manner in which they are grouped, that the neutral point is not exactly in the middle of the bar, but is, as Coulomb has observed, at some little distance from the extremity which has been last magnetised.

It appears, in the second place, that the method of Æpinus produces consecutive points in very long plates more easily than that of Du Hamel. These alternations, indeed, have always very little energy, but they, nevertheless, diminish the directive force, which is a matter of great inconvenience in the construction of compass needles. The same thing may be said of the other small inequality in the distribution of the magnetism; and, therefore, it is much better to magnetise needles by the method of Du Hamel, which is completely exempt from these two faults, and reserve the method of Æpinus for large bars, to which we wish to communicate a very high force, for then it is of little consequence whether or not the neutral point is placed exactly in the middle of the bar.

By thus taking from each of these methods what is most useful, and adding to them the information obtained from long experience, Coulomb arrived at the following arrangements, which are represented in Figs. 40 and 42.

In order to form fixed bundles, he employed for each ten bars of steel tempered cherry red, having a length of about 21 or 22 inches, a breadth of about 6-10ths of an inch, and a thickness of 1-5th of an inch. He magnetised them as much as possible with a natural or artificial magnet, and then uniting them by their poles of the same name, he formed two beds of five bars each, separated by small rectangular parallelopipeds of soft iron, which performed the part of a common armour, and which projected a little beyond their extremities.

The moving bundles he commonly formed of four bars tempered cherry red, about 16 inches long, 1-5th of an inch thick, and 6-10ths of an inch wide. After magnetising them as strongly as possible, he united two of them by their widths, and two of them by their thickness, which gave to each bundle a width of one inch and 2-10ths, and a thickness of 2-5ths.

Both the fixed and moveable bundles were made of steel very common in commerce, called *d'acier timbré à 7 etoiles*. It is of a moderate quality, but Coulomb observed, as had already been done before, that every kind of steel, provided it is not of a very bad quality, takes nearly the same degree of magnetism. We shall only remark, that as bars are always bent a little in tempering, they should be tempered at first as hard as possible, and then annealed to the first shade of yellow. This annealing gives them sufficient malleability for being again brought into shape, and at the same time leaves a coercive force, sufficient for preserving a very energic development of magnetism.

We have found, also, that it is of great importance to ensure an intimate contact between the elementary plates of the large bundles, and the soft iron armour by which they are united. The total action of the bundles, indeed, is only the resultant of the forces of the plates transmitted to the armour by influence, and, therefore, it is necessary that this influence be excited to the greatest possible advantage.

For this purpose, we form the armour of several plates of very soft iron, which cover the elementary plates in the part of their extremities where the repartition of free magnetism is perceptible. All these plates of soft iron make part of a mass of the same nature, terminated in a trapezoidal form, as shown in Fig. 41, and the elementary plates of steel are inserted in it, according to the direction of the dotted lines, so that the plates situated in the axis of the bundles project a little beyond the lateral plates. The whole are bound together with a collet of soft iron, held firmly by a screw.

We have found, from experience, that this arrangement, pointed out by theoretical considerations, is indeed extremely advantageous.

In order to magnetise a needle or a bar of any kind by means of this method, we begin by placing the large bundles in the same straight line, so that their north and south poles are turned to one another, and kept at a distance equal to the length of this bar, as in Fig. 42. Each of its ends is then placed upon one extremity of their armours, in such a manner that it goes very little over it; after that, two moving bundles are placed upon the centre of the bar, and inclined on each side in an opposite direction, so as to form with it an angle of about 20° or 30°. Then, if we wish to employ the method of M. Du Hamel, we must cause each bundle to move over the half of the bar on which it is placed; but if we wish to employ that of Æpinus, we do not separate them, but place them together, with a small piece of wood or of copper between them, in order to keep their opposite poles at a distance of about one-fifth of an inch; and holding them in this manner, with the same inclination as in the other method, they are moved successively from the centre to each extremity, so that the number of frictions or touches upon each half of the bar may be equal. After the last friction, by which they are brought to the centre, they are withdrawn perpendicularly, and the same operation is repeated upon the other surface.

If the bars which compose the bundles have not been at first magnetised to saturation, which will generally happen when we have not at our command an apparatus like the preceding, their assemblage will produce, in bars subjected to their action, a much stronger degree of magnetism than they themselves possess. These new bars may then be used in forming other bundles, stronger than the first; and if we have not yet attained the maximum of energy, we may repeat the operation a third, or even a fourth time, till we have obtained bundles as strong as we can desire.

We have said that each moving bundle was composed of four bars. When we wish, however, to magnetise very thick bars, we must unite a greater number, arranging them in steps retreating about half an inch in the direction of their thickness, as is shewn in Fig. 43. This arrangement is founded on the fact, that the greatest development of magnetism takes place at the extremity of the bars. In this case, the bar nearest to the central one tends to maintain, and even to augment, in its extremity, the development of magnetism which already resides in it. The third bar produces the same effect upon the second, and so on with the rest. This is the same arrangement which we have already shewn in Fig. 41, for the insertion of elementary bars into the armours.

When we have finished the operation either with the system of fixed or moveable bars, we must place the two of each pair parallel to one another, opposing their similar poles, as represented in Fig. 44. The poles are then joined by parallelopipeds of soft iron, which becoming magnetic by influence, neutralises the magnetism of the bundles, and tends to increase rather than diminish it. The effect is precisely the same as that which we have explained above, in speaking of the increase of force which natural loadstones acquire by time, when the feet of their armour are united by pieces of soft iron.

We shall now proceed to establish experimentally the various theoretical considerations which we have already explained, and in doing this we shall take Coulomb for our guide.

In order to appreciate with accuracy the different methods of making artificial magnets, this philosopher proposed to compare them in the different degrees of difficulty which they had to overcome. He applied them at first to wires of tempered steel of a very small diameter, and to thin plates of steel untempered by annealing. This last circumstance facilitates the development of magnetism, by weakening the coercive force. From this he passes to equal plates of a small thickness, but tempered to a cherry-red, when the coercive force is greater, and the difficulty of magnetising them increased; and, finally, preserving always their degree of temper, he tried to magnetise, by different methods, bars of a greater and greater thickness.

In order that this comparison might be made with accuracy, he began by procuring ten bars of tempered steel, having each a length of about 17 inches, a width of one inch and two-tenths, and a thickness of one-fifth of an inch; and he magnetised them, one after another, as strongly as possible, by subjecting each of them to a series of operations, so that their magnetism might be equal.

His first experiment was made with a wire of tempered steel about 12 inches long, and one-twenty-fifth of an inch in diameter. He at first rubbed it at right angles upon the pole of a single artificial magnet. He then made it oscillate in a horizontal plane, by suspending it in a paper dish with an assemblage of several untwisted fibres of silk, in order to observe the intensity of the action exerted upon it by the magnetic force of the earth. He then found, that, in virtue of this action, it performed

10 *oscillations in* 74 *seconds.*

The same wire, when rubbed at right angles upon the pole of four of ten bars united, did not acquire stronger magnetism, and likewise performed

10 *oscillations in* 74 *seconds.*

When magnetised by the method of Du Hamel, and by that of Æpinus, by submitting it to the action of a large apparatus, it always performed

10 *oscillations in* 74 *seconds.*

Hence it follows, that steel wires of a small diameter acquire, by all the different methods, the same degree of magnetism that they do by simple contact. This degree may therefore be considered as the state of saturation.

Coulomb afterwards substituted, in place of a wire, a plate of annealed steel, about 12 inches long, one-third of an inch wide, and one-forty-second of an inch thick; so that it differed only in its width from the preceding wire.

This plate being rubbed at right angles upon the pole of a single magnet, performed

10 *oscillations in* 77 *seconds.*

Upon the pole of two united bars	10 *oscillations in* 75 *seconds.*
Upon the pole of ten united bars	10 *oscillations in* 75 *seconds*
By the method of Du Hamel and Æpinus, employing only a single moveable bar on each side .	10 *oscillations in* 75 *seconds.*

In these experiments, the different effect of the methods begin to be perceptible; but it is still very feeble. It, however, becomes much stronger in passing to the state of temper. A plate of steel about 6.5 inches long, $\frac{9}{25}$ths of an inch wide, and $\frac{1}{42}$d of an inch thick, tempered cherry-red, and rubbed at right angles upon the poles of two united bars, performed

10 *oscillations in* 51 *seconds.*

Upon the poles of five bars united . . . . 10 *oscillations in* 49 *seconds.*

Upon the poles of eight and ten bars united . . . 10 *oscillations in* 47½ *seconds.*

By uniting only two bars, and rubbing the plate upon the poles at an angle of 15 or 20 degrees, in place of a right angle as formerly, which brought their centre of action nearer the surface of the plate, it performed 10 *oscillations in* 47½ *seconds.* When magnetised by the methods of Du Hamel and Æpinus, with only two moveable bars, it performed 10 *oscillations in* 72½ *seconds.* It is deserving of notice, that in employing the method of Æpinus, he commonly found the duration to be a half, and sometimes a whole second, longer than by that of Du Hamel, which arises, no doubt, from the two causes pointed out in p. 19.

In these experiments, as well as in the subsequent ones, we can only draw a comparison between the duration of the oscillations performed by the same plate, successively magnetised by the same methods; for, in different plates, the absolute results are altered by the change of dimension, and by the different degrees of temper.

As the thickness of the plates increases, the difference in the effect produced by various methods becomes more perceptible.

A plate about 8 inches long, $\frac{14}{25}$ of an inch wide, and $\frac{1}{25}$ thick, after being rubbed several times at right angles upon the pole of a single bar, performed

10 *oscillations in* 73 *seconds.*

Upon the pole of four united bars . . . . . 10 *oscillations in* 62 *seconds.*

Upon the pole of ten united bars . . . . . 10 *oscillations in* 59 *seconds.*

But by uniting only two bars and rubbing them upon the plate, at an inclination of 15 or 20 degrees, it performed . . . . 10 *oscillations in* 53 *seconds.*

At the same inclination, with four united bars . 10 *oscillations in* 49 *seconds.*

At the same inclination, with eight or ten united bars . . . . 10 *oscillations in* 49 *seconds.*

By the methods of Du Hamel and Æpinus, with one or more bars on each side . . . . 10 *oscillations in* 49 *seconds.*

These experiments are sufficient to shew that the methods of Du Hamel and Æpinus are superior to all the rest, since they give the same degree of magnetism, with a much smaller number of moving bars. It will be observed, also, that these methods are equally good, when we apply them to plates which are $\frac{1}{25}$ or $\frac{2}{25}$ of an inch thick; but by applying them to greater thicknesses, that of Æpinus has decidedly the advantage. Coulomb made this trial upon one of the large bars of which his bundles were formed. These bars were about 16 inches long, $\frac{6}{10}$ of an inch wide, and $\frac{1}{5}$ of an inch thick, and were tempered cherry-red. By applying to one of them the method of Æpinus, with two moveable bars rubbing upon its surface, it performed

10 *oscillations in* 110 *seconds.*

By augmenting the number of moveable bars, it acquired no more, and had therefore reached the state of saturation. But by the method of Du Hamel, it could not be brought to the same state before employing moveable bundles composed of four bars each.

Coulomb repeated this comparison with a still thicker bar, 16 inches long, 1 inch broad, and $\frac{9}{23}$ths thick. By applying to it at first the method of Æpinus, and forming moveable bundles of one, two, or three bars, it acquired a magnetism progressively increasing; but by employing bundles composed of four bars, or even of ten, or a greater number, it performed

10 *oscillations in* 153 *seconds.*

By employing the method of Du Hamel, it was impossible to attain the same degree of magnetism, even by using bundles of ten bars each. By this operation the bar performed . . . . 10 *oscillations in* 162 *seconds.* The first method, therefore, gave a greater magnetic force, in the ratio of $(162)^2$ to $(153)^2$, or of 9 to 8.

The method of Æpinus is consequently the only one which should be employed in magnetising bars of this size, or in making artificial magnets of great strength. It would be of little avail to increase, beyond this limit, the thickness of the bars in a magnetic apparatus; for experience proves that a much greater degree of strength may be obtained by uniting several small bars separately magnetised—a fact which no doubt arises from the circumstance, that we are able to give to each of these bars individually a much higher degree of magnetism, than we could do if we wished to act upon them when they were included in the centre of a thicker bar. The preceding observations relate only to the methods of making artificial magnets when the bars of steel are cold; but it is probable that a much higher degree of magnetism could be developed by raising the temperature of the bar, at the instant of its being magnetised, or even by modifying its constitution. The first method was pointed out, as we have already stated, by Dr. Robison*; and the second was employed by Dr. Knight with so much success, that it deserves to be again examined by accurate experiments.

The method of Dr. Knight consisted in forming bars with an artificial paste, the composition of which was published after his death by Mr. Benjamin Wilson†, and is as follows:

" Having provided himself with a large quantity of clean filings of iron, Dr. Knight put them into a large tub that was more than ⅓d filled with clean water. He then, with great labour, worked the tub to and fro for many hours together, that the friction between the grains of iron by this treatment might break off such smaller parts as could remain suspended in the water for some time. The obtaining of which very small particles in sufficient quantity seemed to him to be one of the principal desiderata in the experiment. The water being by this treatment rendered very muddy, he poured it into a clean earthen vessel, leaving the filings behind, and when the water had stood long enough to become clear, he poured it out carefully, without disturbing such of the iron sediment as still remained, which now appeared reduced almost to impalpable powder. This powder was afterwards removed into another vessel, in order to dry it; but as he had not obtained a proper quantity by this first step, he was obliged to repeat the process many times.

Having at last procured enough of this very fine powder, the next thing to be done was to make a paste of it, and that with some vehicle which would contain a considerable quantity of the phlogistic principle. For this purpose, he had recourse to linseed oil, in preference to all other fluids. With these two ingredients only he made a stiff paste, taking particular care to knead it well, before he moulded it into convenient shapes. Sometimes, while the paste continued in its soft state, he would put the impression of a seal on the several pieces; one of which is in the British Museum. This paste was then put upon wood, and sometimes on tiles, in order to bake or dry it before a moderate fire, at about a foot distance. The Doctor found that a moderase fire was most proper, because a greater degree of heat made the composition frequently crack in many places.

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* Robison's *System of Mechanical Philosophy*, vol. iv. page 248, 333. † *Philosophical Transactions*, 1779, vol. lxix. page 51.

The time required for the baking or drying of this paste was generally five or six hours before it attained a sufficient degree of hardness. When that was done, and the several baked pieces were become cold, he gave them their magnetic virtue in any direction he pleased, by placing them between the extreme ends of his large magazine of artificial magnets* for a few seconds, or more as he saw occasion. By this method, the virtue they acquired was such, that when any one of these pieces was held between two of his best ten guinea bars, with its poles purposely inverted, it immediately of itself turned about to recover its natural direction, which the force of those very powerful bars was not sufficient to counteract."

It appears from this description, that Dr. Knight's method consists in procuring a very fine powder of iron, a little oxidated, all the particles of which he united by means of linseed oil, or any other substance fitted to give them a suitable degree of oxygenation. When the paste thus formed was magnetised, each particle of the powder became a small magnet, in which the development of the magnetism might be very powerful, on account of the suitable degree of coercive force produced by the oxygenation; and the homogeneity of this state in all the particles, as well as an extreme tenuity, might give to the whole system the most favourable arrangements for receiving a high degree of magnetism. We obtain a somewhat similar effect, by forming magnetic bars with steel of a very equal and homogeneous grain; for the carbon, which is there combined with the iron, acts like oxygen, in giving to the particles a coercive force; but this degree of combination probably does not admit of a development of magnetism as considerable as that of the ferruginous paste, and probably this paste is more homogeneous in its texture than that of the best steel. There is some reason to believe, that it is the union of similar qualities, which gives to some pieces of natural magnets a degree of strength which cannot be obtained from bars of steel of the same dimensions.

If, after having magnetised, by the method of Du Hamel or Æpinus, a steel wire 15 or 20 inches long, and one or two lines in diameter, we examine what weight it is capable of supporting in different points of its length, we shall find that these weights go on increasing from the extremity of the wire to a distance of *four* or *five* lines, beyond which it diminishes rapidly, so as to become almost insensible at the distance of *two* or *three* inches from the extremity. These weights will also be found equal towards each end of the wire; and therefore it follows, as we had foreseen, that the most intense quantities of free magnetism are distributed towards the two extremities, and at a small distance from them, and that they are perceptibly equal there,—a distribution perfectly analogous to that of free electricity in the tourmaline, or in electric piles.

This important result may be proved in the most satisfactory manner by the balance of torsion. A steel needle, of a rectangular shape, well magnetised by the method of Du Hamel or Æpinus, must for this purpose be placed in the stirrup of the magnetic balance. In the direction of the magnetic meridian of this needle, which ought to correspond to the zero of torsion, a vertical rule of wood or copper, one or two lines thick, is fixed so that the needle may come against it, when it is brought back to its magnetic meridian. On the other side of this rule a magnetised wire of steel, such as we have above described, is made to pass vertically, so as just to present its homologous pole to that of the needle. The needle will at first be driven away by the repulsion of the two opposite magnetisms, but it is forcibly brought back into contact with the rule, by twisting the suspending wire in such a manner that there remains only the thickness of the rule, or a distance of about two lines between the nearest points of the needle and the magnetised wire. But since this wire which we have placed behind the rule is vertical, while the needle is horizontal, all the points on each side, which are four or five lines distant from the crossing of both, contribute only a very little to the repulsion, on account of the distance and the obliquity with which they act; so that the force of torsion which we must employ in order to maintain the contact, ought to depend particularly on the quantities of free magnetism which exist upon each needle, from the point of contact to a distance of two or three lines on each side of this point. By thus making the steel wire pass vertically along the rule, and presenting successively all its points at the small distance of two lines from the same point of the needle, whose action remains constant, the force of torsion which it is necessary to employ in order to keep up the contact, will be, at each trial, a very exact measure of the intensity of the free magnetism on the point of the wire which lies in the crossing. In making this experiment, it will be found, that if *eight* circles of torsion are necessary when the intersection is two lines from the extremity of the wire, *two* or *three* circles only, will be necessary at two inches; and when the extremity of the wire is three inches above or below the horizontal plane of the needle, the repulsion is almost nothing. It follows, therefore, from this trial, that the free magnetism is chiefly concentrated upon the three first inches from the extremity of the steel wire. The same result will be obtained from the attraction of poles of an opposite name, and if the vertical wire has been regularly magnetised by the process of double touch, it will be found that the attraction of this pole is perceptibly equal to the repulsion of the other; but it is necessary to observe, that in order to obtain correct results, we must employ only needles and wires of excellent steel strongly tempered; and we must take care not to give them a very strong degree of magnetism; for without these precautions, the points of intersection being only two lines apart, the reciprocal influence of the needle and the steel wire may develop in these points new quantities of magnetism, so that the results of the attractions and repulsions could be compared with one another.

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* What Dr. Knight here calls his magazine of magnets, consisted of two systems of bars magnetised in the strongest possible manner, and united in each system by poles of the opposite name. The compound bundles employed by Coulomb, and which we have above described, formed an apparatus of this kind.

If in the preceding experiment we substitute in place of the wire and the needle two similar wires, 24 inches long, and placed so that their points of intersection are 10 or 12 lines from the extremity of each, then by joining their homologous poles there will be a repulsion. But this repulsion will be almost entirely produced by the two or three inches of length upon which the magnetism is most developed, and the poles which are joined will be almost the only ones that contribute to it; for the action of the two others will be extremely weak, both on account of the length of the two wires, and on account of the obliquity of their direction, which will be considerable if the two crossing poles are placed at a short distance. These poles are therefore placed in the most favourable manner for determining the law of their repulsion at different distances; for as they cross each other in the points where the repulsion is the strongest, the other portions of free magnetism which are situated near these points will have almost the same effect upon the repulsion as if they were all concentrated there, so that we shall have nearly the reciprocal action of two points, each of which is charged with a constant and given quantity of magnetism of the same kind.

When, in the preceding experiment, the moveable wire is separated from the fixed one, it will be drawn towards it, not only by torsion, but by the attraction of the terrestrial magnet, which tends to bring it back to its magnetic meridian. We must therefore begin by measuring separately this directive force for the different distances, and afterwards add it to the observed torsion, in order to have the total effect of the repulsion of the two poles. The following are the results of an experiment of this kind, as made by Coulomb.

Having taken two wires 24 inches long, and 1½ line in diameter, he put the horizontal one first in its place, and by the method we have mentioned, he determined the force with which the terrestrial magnet drew it back to the magnetic meridian. For this purpose, he turned the micrometer of suspension two circles: The needle advanced 20°, and therefore the torsion was two circles *minus* 20°, or 700°. Here we may easily deduce the directive force for any other angle α; for it is proportional to the sine of this angle, and therefore its value is $700.\frac{\sin.\ \alpha,}{\sin.\ 20°.}$ But as the sines of small angles are nearly proportional to the arcs, we may, without any perceptible error, substitute them in place of the sines, when we limit the repulsions to below 24°. The expression of the directing force will then become $\frac{700\,\alpha}{20}$, or $35\,\alpha$; that is to say, that, within these limits of amplitude, Coulomb was obliged to twist the suspending wire nearly 35°, to draw the horizontal magnetic wire one degree from its magnetic meridian. Coulomb now placed vertically in this meridian another magnetic wire of the same dimensions as the first, that, if the two wires had touched, they would have met at the distance of an inch from their extremities; but as their homologous poles were opposed, the horizontal wire was repelled from the direction of its meridian, and it only stopped when the force of repulsion of the opposed poles was balanced by the combined forces of torsion and terrestrial magnetism, which tended to bring the horizontal wire to its point of rest. The following were the results of different trials:

Circles of Torsion given to the suspending wire, by means of the Micrometer.	Observed angles of Repulsion.
0	24
3	17
8	12

The first experiment expresses the angle through which the moveable wire was immediately driven, reckoning from the zero of torsion. When it stopped in this position, it was driven towards the zero by a force of torsion of 24°, *plus* the directive force of the terrestrial magnet for 24°, which is $24\times35°$, or 840°. The total repulsive force was therefore 864°.

In the second experiment, the micrometer was turned three circles in a direction contrary to the 24° first produced; but in spite of this great torsion, the moveable wire, repelled by the fixed one, returned only to 17° from its magnetic meridian; so that the force of torsion was then 3 circles + 17° or 1097°, and adding to this the directive force for 17°, which is $17\times35°$, or 595°, we obtain for the total repulsive force 1097° + 595°, or 1692°.

In the third experiment, the wire was twisted through eight circles. The magnetic wire stopped at 12° from its magnetic meridian; and therefore the torsion was eight circles + 12°, or 2892°, to which adding the directive force, or $12\times35°=420°$, we have for total repulsion 3312°.

In these experiments, therefore, when the arcs of repulsion are sufficiently small, so that they may be reckoned equal to their chords, the distances were 12; 17; 24

And the corresponding repulsive forces measured in degrees of torsion 3312°; 1692°; 864°

From these results, it appears that the repulsive force diminishes as the distance increases, and that it diminishes more rapidly than in the ratio of the simple distances; for the third distance, 24, is double of the first, and the repulsive force, 865, is much less than half of 3312. Let us try, therefore, the inverse ratio of the square of the distances; and in setting out from the first force, 3312, they ought to be $3312\ \frac{(12)^2}{(17)^2}$, and $3312\ \frac{(12)^2}{(24)^2}$, or 1650, and 828, in place of 1692°, and 865, as obtained by the experiment. The differences 42° and 36° correspond nearly to a degree of error in the observed positions of the moveable steel wire, since the directive force is 35° for each degree of deviation from the magneic meridian. Neglecting, therefore, this error, which we may consider as very small in experiments of this kind, we may conclude that the reciprocal action of two magnetic wires decreases as the square of the distance increases; and, consequently, the magnetisms of the same kind, by which this action is produced, repel one another also according to this law.

The small deviation which we have found between the observed and calculated repulsions does not perhaps arise even from an error of experiment, or any want of exactness in the law which we have deduced; for the experiment is made, not upon magnetic points, but upon portions of the wire of a certain extent, the configuration of which has an influence upon the results. In the last experiment, indeed, where the two wires were nearest each other, the influence of the points lying near the intersection was more weakened by obliquity than in the other experiment; or, in other words, there was at equal obliquities more points which acted in the greater distances than in the smaller ones. But as we did not take this augmentation into account, we ought to find that the repulsive force observed at the smallest distance, being reduced in the ratio of the square of the distance, gives for larger distances repulsive forces a little more feeble than those which were actually observed.

The same experiment, repeated with the poles of an opposite name, shews that they attract one another in the inverse ratio of the square of the distance. This law of attraction and repulsion is therefore the same in magnetism as in electricity.

It follows from these results, that Coulomb has legitimately omitted in his experiments the action of the distant poles; for as the needles were two feet long, the greatest arc of repulsion, which was 24 degrees, corresponded to a distance of 5 inches between the poles which were directed to each other; and, consequently, the other poles were at least four times more distant from those which were directed to each other, than these poles were from one another. Their direct action consequently was at least sixteen times weaker; and it was even still more weakened by the extreme obliquity of the direction in which it acted. The case would not be the same, if the experiment had been made with shorter wires. It would then have been necessary to have taken into account the reciprocal action of the two poles, and the length of lever by which each of them acted. This would not have been difficult, by considering all the poles as containing equal quantities of magnetism—distributed over a small space near the extremities of the wires, and acting in the inverse ratio of the square of the distance. The intensities and directions of their forces, whether attractive or repulsive, would then have been known, and we would have had only to reduce them to the horizontal plane of the moveable wire, in order to have the effects which they produced upon its rotation; but it was much more simple to avoid these corrections by making the experiment on wires sufficiently long, as it had also the additional advantage of diminishing the little inaccuracies arising from the perceptible extent of the poles over which the magnetism is distributed.

Coulomb confirmed the law of the squares of the distances by several methods different from that which we have explained; but as this is sufficient for establishing the law, we must refer the reader for an account of the rest to the different memoirs which he published upon the subject in the *Memoirs of the Academy of Sciences.* We shall here subjoin a few reflections on the attempts of the same kind, which had been previously made by other philosophers.

The diminution of the attractions and repulsions exerted by a loadstone, when it was made to act at a greater distance, was a phenomenon so striking, and of such primary importance in all magnetical experiments, that it ought to have attracted the attention of all observers. We find, accordingly, that it was noticed by Gilbert; and, even before his time, J. B. Porta had tried to measure the power of a magnet, by opposing it to gravity. For this purpose, he fixed a magnet above one of the scales of a balance, in such a situation, that, turning one of its poles to the earth, it was in equilibrium with the weight placed in the other; he then placed upon the table, which supported the balance, a mass of soft iron exactly below the suspended magnet. The attraction of the magnet for the iron having caused it to descend into contact with it, this force drew away the scale of the balance, and the equilibrium was destroyed. He then placed new weights in the other scale, till their efforts were again able to detach the magnet from the mass of iron; and the total weight necessary for producing this separation with different magnets gave a comparative measure of their energy.*

This method might also have been adopted for measuring the action of the same magnet out of contact, and for determining the decrease of the attractive force. It was necessary only to place below the suspended magnet a stop, to limit its descent to the same fixed position, and to bring successively the mass of iron to different distances below it. This plan was adopted by Muschenbroek; but though his experiments appear to have been made with care, and though he took the precaution to give both to the magnet and to the mass of iron a cylindrical form, for the purpose of rendering the mode of action similar at different distances, he was not able to deduce from it the true law of the forces; and it is easy to see the reason of his failure, when we consider how complicated this method of making the experiment really is, notwithstanding its apparent simplicity. The mass of iron is obviously not solicited merely by the lower pole of the suspended magnet, but also by the upper pole, though with less energy. This action is also exercised in virtue of a decomposition of the natural magnetisms of the mass of iron, which thus acquires two poles, whose combined efforts have an influence upon the intensity of the reciprocal attraction of the two masses. These poles, indeed, both in the magnet and in the iron, are not really two mathematical points; they are two perceptible spaces, in which the free magnetism exists, and is distributed with variable densities. It is manifest, however, that the total tendency of the suspended magnet towards the fixed iron, a tendency which is measured by the weight necessary to balance it, results from the union of all these complicated circumstances, and therefore we cannot expect to deduce from it the law of the forces, so long as we cannot discover from the total effect the manner in which these forces contribute to it. This decomposition was impossible, from the state of the science at the time when Porta, Gilbert, and even Muschenbroek, wrote; and it would be difficult, even in the present day, by adopting the same form of the experiment as Muschenbroek, who was able only to draw vague and incorrect conclusions, viz. that the energy of the attraction decreases with the distance, in a proportion less than that of the square of the distance; a proportion which, according to him, is unequal in different magnets, and even for the same magnets at different times. Before Muschenbroek made his experiments, Hawksbee had employed a more ingenious method, which consisted in opposing the constant magnetic force of the earth to the attractive force of the same magnet, rendered variable by a change of distance. For this purpose, he suspended horizontally a magnetic needle in the direction of the magnetic meridian, and he observed the deviations which it experienced, by the action of a magnet placed in the same horizontal plane, and removed successively to different distances. In this experiment, the position where the needle stops, is that in which the opposite magnetic actions of the earth and the magnet are equal, and therefore in equilibrio; but we see from this very circumstance, how much complication there is in this result. It depends, in the first place, as in the experiment of Muschenbroek, on the reciprocal actions of the two poles of the magnet upon the two poles of the needle, and it depends also on the directive action of the terrestrial magnet upon this needle, the exact law of which must be previously determined. But, what renders the application of this experiment still more uncertain, the artificial magnetic force is here measured by the terrestrial directive force, which is extremely feeble. Hence we are obliged to weaken that of the magnet by distance, in order to render the two comparable, which compels us to operate upon small forces, and increases all the sources of error. From this cause Hawksbee, Brook Taylor, and Whiston, all of whom employed this method, obtained from it no positive results, and even differed considerably in their conclusions. It is probable also, that it was from complicated phenomena like these, that Newton concluded that the magnetic force varied as the cube of the distance.* (*Philosoph. Nat.* lib. iii. prob. vi. cor. v.) The reciprocal effects of the direction produced by two magnets placed at great distances from one another, compared with their dimensions, decrease indeed according to this law; but this result does not express the law of the magnetic forces, in the same manner as the law of celestial attraction is not expressed by the cube of the distances, although it is according to the cube of the distance that the phenomena of precession and nutation vary, as determined by the spheroidal figure of the attracting bodies. The ingenious Lambert tried also his sagacity on this delicate question, in the *Memoires de Berlin*, for 1766. For this purpose he employed the same mode of experiment employed by Hawksbee, which we have already described. The force which he opposed to the terrestrial magnetism, was that of a small natural magnet, of nearly a cubical figure. By placing at first this magnet at constant distances from the needle, but in such a manner that its action was differently inclined to that of the terrestrial magnet, he discovered that the directive force was sensibly proportional to the sine of the obliquity, a result which was completely confirmed, in all its rigour, by the experiments of Coulomb, which we have already explained. This result being known, Lambert removed his magnet to different distances from the needle, and calculating the statical momentum of the terrestrial directive force by the laws of the sines for each of the directions thus observed, he obtained the proper effect of the loadstone on the needle in these different circumstances; and he found that this effect followed nearly the inverse law of the square of the distance. But after what we have already said, this effect itself was still very complicated, and there was much to do in order to deduce with sufficient accuracy the simple law of the forces themselves. Lambert himself saw this; but wanting the experimental data necessary for arriving at this simplicity, he tried to shew that the composition itself of the phenomena ought to modify the law in the direction where it was altered in his experiments. His researches therefore prove that the law of the forces approach nearly to that of the square of the distances, but they were not sufficient to determine it with exactness. It is obvious, however, that it is the precise determination of the law which constitutes the essence and the principal merit of the discovery, because it is this which permits us to introduce it as a mathematical law into all the calculations of the complicated phenomena.

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* We have given this experiment of Baptista Porta, as it is described by Dr. Gilbert, lib. ii. cap. 36.

The best proof which can be given that Lambert had not given a final solution of the problem is, that so learned a philosopher as Dr. Robison undertook a new investigation of the subject. The method of observation employed by Dr. Robison appears to have been nearly the same as that of Hawksbee; only, in order to diminish the complication of the action resulting from the distance of the two poles of the magnet, which was employed for opposing the terrestrial force, he used spherical magnets of equal volume, placed at the extremity of a beam not magnetic. It appeared to him that the action of these magnets ought to produce a resultant of forces emanating from the centre which would render the calculation of their effects more simple. It is not easy to conceive how this simplification took place; but however this may be, it appears that, after a great number of calculations, founded upon this method of making the experiment Dr. Robison remained convinced, like Lambert, that the magnetic force decreased as the square of the distance; but this conviction seems to have been rather the result of a happy conjecture of this skilful observer, than the precise consequence of demonstration.

It is manifest from the bare recital of these successive trials, that Coulomb was really the first who demonstrated in a rigorous manner the simple law of the magnetic forces; and if we reflect on the progress of his researches, we shall see that it was impossible to arrive at the result in any other manner than by the succession of discoveries by which he obtained it.

It was necessary, indeed, to determine previously the exact law of the terrestrial directive force which inevitably mingled with all the experiments; and he did this by opposing that force to the force of torsion. It was necessary, also, to have a fixed method of making artificial magnets, which gave to the development of magnetism an arrangement always the same, and the most energetic possible. For this purpose, he compared the results of different methods by the aid of oscillations, and he found that that of the double touch, aided by the influence of fixed magnets, had all the advantages which he required. It was necessary, then, to know how the free magnetism, developed by this method, was distributed, in order to understand how its total quantity acted. He arrived at this result by studying with his torsion-balance the energies of the reciprocal actions exerted by different points of bars thus magnetised, and he was thus satisfied that the free magnetism was accumulated in long bars at a small distance from their extremity. Hence he was able to place these bars in a situation where two of their poles only exercised a perceptible action on one another; and at last, by balancing this action with the force of torsion for different distances of these poles, he was able to obtain the same result as if he had operated upon simple points. In this way he found that the action, whether attractive or repulsive, was exactly reciprocal to the square of the distance, and that this rigorous law might be introduced as a principle into the theory of compound magnetic effects, in the same manner as gravitation, deduced by Newton from the laws of Kepler, had been introduced into the calculation of the celestial phenomena.

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* It is obvious from the scholium of the XXIII. Prop. of the 2d Book of the Principia, that Newton was very far from having accurate ideas respecting the magnetic phenomena.

It is curious to remark, that the old method of Porta alone might even now be employed for confirming the law of magnetic attractions and repulsions, as discovered by torsion, provided that we make, upon the first arrangement of this ancient observer, some slight modifications necessary for simplifying the phenomena, and for rendering the results calculable. It would be necessary, for example, to replace the magnet and the mass of iron which Porta used, by two magnetic bars about 24 inches long, and formed of steel highly tempered. After having magnetised these two bars, by the method of double touch, one of them, AB, must be fixed horizontally in one of the scales of a good balance, as represented in Fig. 45, so that its south pole, A, for example, is under the axis of this scale, and its length perpendicular to the plane in which the balance oscillates. When this is done, an exact equilibrium of the system would be effected, by placing weights in the other scale P′, and having then disposed the second magnet A′B′ in a horizontal situation perpendicular to AB, and consequently parallel to the plane of the balance, let the north pole B′, for example, be brought under the south pole A, so that the extremities of the two magnets mutually pass one another by one or two inches, as in the experiment of Coulomb, which we have described. As the poles A and B′ attract one another, the equilibrium will be destroyed: and, in order to re-establish it, we must put new weights into the scale P′. By repeating this experiment at different distances from the magnet A′B′, we shall find that these weights become smaller and smaller in proportion as A′B′ is removed, and the comparison of these weights will give the law of the decrease of the reciprocal action at different distances; for in consequence of the length of the magnets, and their almost perpendicular arrangement, the distant poles B,A′ will have an influence on the result nearly inperceptible; and we may, in case of necessity, value it afterwards by calculation, and add it as a correction to the principal effect, when the law of the forces shall have been demonstrated by the results themselves. By taking care to employ only very hard tempered bars, or rather wires of steel, their mutual action shall not produce any new development of magnetism, so that the reciprocal action of the poles that are brought near one another will be due only to the constant quantities of free magnetism originally excited during the process of magnetising them. In the description of the experiment, we have supposed that the two poles of opposite names were brought together; but we may also employ similar poles, and obtain repulsions that may be measured in the same manner, with this difference only—that it will then be necessary to add the weights to the scale P, which carries the magnet AB. It is obvious that this method absolutely returns to that of Coulomb, excepting that the effort of the two magnets to separate or to approach each other is measured by weights, the valuation of which depends on the sensibility of the balance; whereas, in the method of Coulomb, the effort is measured by the torsion of a wire, which may be as sensible and as delicate as we please.

Having found infallible methods for developing, in bars of iron or steel, all the magnetism which they can acquire, and for preserving it in a durable manner, we shall now determine experimentally the magnetic state of each of these points.

For the sake of simplicity, we shall begin with the case of a cylindrical steel wire A B, fig. 46, of a very small diameter, and regularly magnetised, by the method of the double touch. The development of magnetism will then be perceptibly equal, but of an opposite nature in each of of its two halves, and will decrease rapidly in each of them, from their extremities towards the centre. If we, therefore, erect, at different points of the wire, perpendicular ordinates, to represent the intensity of free magnetism, whether boreal or austral, these ordinates will commence by being nothing at the centre, from which they will go on, increasing equally and slowly on both sides of the axis. At a certain distance, these ordinates will increase rapidly towards the extremities of the wire, where they will reach their maximum. This is all that our preceding experiments permit us to conjecture.

In order, however, to determine the value of these ordinates, we must suspend, by a single fibre of silk, a small trial needle *a b*, fig. 47, previously magnetised; and, after having allowed it to place itself in the magnetic meredian, we must present to it, in the same meridian, the wire AB, held vertically at a small distance from the pole *a*. This operation will not change the direction of the needle *a b*; but if we make it deviate, in the least degree, from its meridian, it will return to it more rapidly than when the wire did not act upon it, because it is drawn back by the combined action of the earth and the wire. The first of these forces may be easily measured, by making the needle oscillate by the sole influence of terrestrial magnetism; it will be proportional to the square of the number of oscillations which it makes in any given space of time, such as a minute. If we afterwards observe, in the same manner, the number oscillations, which the needle performs, when acted upon, both by this force, and by that of the wire, we shall obtain, in like manner, by the square of this number, the total action which it experiences; and, by subtracting the first square, depending on terrestrial magnetism, we shall have a seperate measure of the action exerted by the wire. But, in this case, the point M, situated opposite to the needle, will have the most powerful effect, both because it is nearest to the needle, and because it attracts it directly in the horizonal plane in which it oscillates; whereas, the other points, situated above and below it, act at a greater distance, and with a greater obliquity. The influence of these two causes, indeed, is very feeble for the points of the wire which surround M; but, if the action of one of these points is stronger than that of M, that of the point situated on the other side, at the same distance, will be weaker by nearly the same quantity; for, whatever be the nature of the curve A′CB′, fig. 46, which joins the different ordinates, we may always, when we consider a small portion of it, substitute the straight line which touches it. In virtue, therefore, of this substitution, half the sum of the equidistant actions exerted by the points near M, will differ very little from that of M; and therefore it follows, that in each experiment, the part of the wire whose action is most energetic will exert a total force, almost exactly proportional to that of the point M, and consequently to the quantity of magnetism which exists in a state of liberty. This proportionality, however, must not be extended to the extremity of the wire, nor even to a small distance from it; for then the points situated beyond the wire become so near, that their absence is sensibly felt; and consequently, the action experienced by the trial needle cannot be the same as if the wire was continued. When the needle oscillates, for example, before the extremity B itself, the force which solicits it is only one-half of that which would act upon it, if there had been in the prolongation of the wire another equal wire; and consequently, the observed forces will be nearly one half of those which would have been obtained, if the needle had been continued with the law of magnetism which it possesses. In order, therefore, that the results observed in this circumstance may be comparable with those which the needle presents when it oscillates before the other points, where the wire acts upon both from above and below, it will be necessary to double the number which represents the square of the oscillations. This is what Coulomb himself did; and we have satisfied ourselves, by an exact calculation, that this correction is very near the truth.

It is necessary here to notice an objection which may now naturally present itself. When we determined the law of magnetic attractions and repulsions, at different distances, we supposed that all the magnetism of the same pole acted entirely in the horizontal plane of the moveable needle, as if it were nearly concentrated in a single point; whereas we have now said, that the action of the different points of this pole, which are above and below the plane of the needle, will be greatly weakened by the obliquity. The reason of this is, that, in these two cases, the distance of the moveable needle from the fixed wire is very different. In our experiments upon magnetic actions, the pole of the moveable needle was always removed to a considerable distance from the fixed needle, compared with the space over which the free magnetism was distributed. In the present case, on the contrary, this space is considerable, relative to the distance of the small needle, which is very near the wire. This modification renders the influence of obliquity much more considerable. The action of the points situated above and below the plane of the trial needle, decreases, therefore, with much more rapidity. The total action is always nearly the same as if the wire were continued indefinitely on both sides of the plane of the needle, and with the same magnetic intensity which resides in the point that is actually before it. Hence we see why the action thus observed is sensibly proportional to the quantity of free magnetism which exists in this point.

In making these experiments, two important precautions are necessary. The first consists in employing wires so long, that, in reducing the action of one of their extremities upon the needle, there may be no occasion to take into account the action of the other extremity. The second precaution is, that the needle, though small and easily moveable, may also be sufficiently strong, and made of steel sufficiently hard, that its magnetism may not be perceptibly modified by the action of the wire; for if this change did take place, the experiments made before different points would not be comparable, since the part of the action which depends on the needle would vary. This actually happened to Coulomb in his first experiments, when he employed a small trial needle two lines long, and placed at the distance of three lines from the wire. This needle, abandoned to the sole action of the terrestrial magnet, gave very feeble indications of magnetism; but when it was placed at the distance of three lines from the wire, its magnetic state increased considerably, and by presenting it to each extremity of the wire, it suddenly changed its poles.

Warned by these phenomena, Coulomb employed a more powerful trial needle, which was three lines in diameter, and six lines long. The diameter of the magnetic wire was two lines, its length 27 inches, and its weight 865 grains per foot. In order that it might not produce any change on the needle, he held it at a greater distance, namely 8 lines, and measured the number of oscillations which it performed in a minute, when it was held before different points of the wire. Having previously observed the number of oscillations which it performed in the same time by the single action of the terrestrial magnet, the difference between the squares of these numbers expressed, in each experiment, the reciprocal action of the wire and the needle; an action which, as we have already said, ought to be nearly proportional to the intensity of the free magnetism in the point of the wire before which the needle had oscillated. By placing these results upon the corresponding abscissæ, Coulomb obtained the curve of intensities represented in Fig. 48. The ascending form of this curve confirms all that the preceding experiments have led us to anticipate respecting the distribution of free magnetism, and the great intensity of its development towards the extremities of the bar.

Coulomb repeated the experiment with the same wire, having changed only its length, all other circumstances remaining the same. He then found, that whatever this length was, provided that it exceeded 6 or 7 inches, the three first and the three last inches gave always nearly the same results as the wire 27 inches long; so that the intensity of the free magnetism was sensibly the same, from the extremity of these wires, to a distance of three inches, after which it became equally weak and insensible in all of them; or, in other words, the curve of the intensities was merely transported to the extremities of the wire, without changing its form in this part, and it was only after having descended near the axis, that its ordinates began to vary more or less slowly, so as to become nothing at the centre of the wire. This constancy in the extreme ordinates for all wires of the same kind and of the same size, indicates clearly that the free magnetism has received in this part a degree of development which it could not exceed, a result perfectly conformable to the idea which we have given of the state of saturation. Coulomb found less constancy in the small ordinates of the curve near the middle of the wire, and he even found, that in very long wires these ordinates varied accidentally, sometimes passing from positive to negative, a result easily understood, if we consider that all these inversions constitute as many possible states of equilibrium, and that the slightest circumstance, such as a contact more or less prolonged during the process of magnetising the wire, or even the action of the poles of the wire itself upon its centre, is sufficient to develope them. In considering the curve of intensity, as traced by Coulomb, it is easy to see that it results from the combination of two curves, which geometers call logarithmics, which, setting out from each extremity of the magnet, would have their ordinates equal, and in an opposite direction, as shown in Fig. 49. The variations, indeed, of the intensities calculated in this manner for different distances from the centre of the wire, is found perfectly conformable to observation. This law, considered analytically, indicates, a distribution of free magnetism exactly similar to that of the two electricities in insulated electrical piles, when the absorbing action of the air has equalized the tensions of their poles; and this is indeed what we ought to expect, from the perfect analogy which we have remarked from the beginning of this article between magnets and piles of this kind. The formulæ deduced from this approximation permit us to trace the variations of the magnetic charge in wires of the same magnitude, but of unequal lengths, and in wires of the same length and of unequal magnitude; and, in short, in wires of any magnitude and length whatever, by supposing them always magnetised by the method of double touch. The consequence resulting from a comparison of the calculated and observed results cannot, however, be explained here, but the reader will find it in my *Traité de Physique*.

The experiments of Coulomb, upon which these calculations rest, present an equal and opposite distribution of magnetism in the two halves of the needle; a distribution which is indeed the most advantageous in order to obtain considerable directive force, and which, therefore, we ought always, if possible, to produce. Experience, however, informs us that this is impossible in tempered needles, when their length is very great, compared with the diameter of their transverse section.

In this case, whatever method of magnetising is employed, several centres are formed in these needles, the development of which is probably owing to the reaction of the poles upon the points near the centre. In this case, the curve of the intensities is no longer situated for each half of the needle on each side of the axis. It necessarily undulates above and below it, as is represented in Fig. 50; and, consequently, its form can no longer be represented by the same analytical expression as before, Fortunately, there is every reason to believe that this limitation is not to be regretted. For, in the first place. it does not happen in annealed needles, unless, perhaps, their length is very much greater than those which are ordinarily used; and with respect to tempered needles, if we are not constrained by some urgent motive to make them extremely light, there will always be an advantage in giving them a sufficient thickness, in order that the free magnetism may be of the same nature in each of their halves; for, at equal intensities of the coercive force, the development of the consecutive centres always weakens the statical momentum of the directive force for each half of the needle, and renders the action less energetic at equal distances from the poles.

It is obvious, in general, that the distribution of magnetism in a needle, and the absolute degree of saturation of which it is susceptible, depend not only on its dimensions, but also on the greater or less temper which it has received. Coulomb had studied the influence of this last circumstance, in a series of experiments which are given in my *Traité de Physique*. He shows that we must always begin by tempering the needle at a white heat, whatever be its dimensions, and then, if its length is less than thirty times its thickness, we must leave it at this temper; but if it exceeds this proportion, we must bring it back again, by annealing, to the state of dark red, in order to avoid a multiplication of centres which its great length might produce. From this principle we may deduce the form and constitution best adapted for compass needles, in order that they may best answer the purpose to which they are destined. But we must defer this subject to our article on the variation of the needle, to which it specially belongs.

One of the most useful applications which can be made of the magnetic forces is, to employ them in detecting the presence of iron in mineral substances, with which the metal may be mixed. This object may be obtained in several ways. When the portion of iron is considerable, and the metal is not strongly combined with oxygen, or any other substance, the approach of a magnet is sufficient to indicate its presence, particularly when the mineral is reduced to powder, as the grains of this powder are sensibly attracted. We may even make this trial, in a manner still more delicate, without destroying the mineral by pulverisation, by trying if it has any influence upon a small magnetic needle, suspended freely and horizontally by a single fibre of silk. In this case, however, it is necessary to enclose the apparatus under a glass receiver, which shields it from the agitation of the external air, a sufficient aperture being left in the sides for introducing the bodies which we wish to try. If these bodies have any sensible magnetic force, they will turn the needle from the direction in which it is held by the feeble action of terrestrial magnetism. But in proportion to the sensibility of this apparatus, we must take greater care in preventing the accidental motions which a change of temperature in the exterior air may excite; and the only method of doing this is to admit as decisive, those variations of position only which are observed at a distance with a fixed telescope. In making use of an apparatus of this kind, without taking the necessary precautions, Cavallo has found that almost all substances give indications of magnetism, and he has even supposed that brisk chemical effervescence produces similar effects. Mr. Bennet, however, has disputed the exactness of these results, by showing that the motion perceived by Cavallo, in his needle, might have been the effect of agitation in the air of the receiver, in virtue of some variations of temperature produced by the proximity of the observer himself, or the substances employed. Mr. Arderon, an English philosopher, had, long before the time of Cavallo, announced that copper was magnetic, in consequence of his having observed that pieces of this metal had exerted an action on very delicate needles, particularly after these pieces had been hammered: but in order that these experiments might be conclusive, the authors should have carefully analysed the copper, and the other metals which they employed, and should have stated the degree of purity to which they had brought them; for it is well known that all bodies, particularly the metals, contain almost always a small quantity of iron, which, when presented before a very sensible magnetic apparatus, ought necessarily to develope their action. All these attempts, therefore, for investigating the generality or the limitation of the magnetic properties were insufficient, when Coulomb undertook, in 1802, to submit this question to a new examination. The apparatus which he employed was extremely simple and accurate.

Out of the substances which he wished to try, he formed small needles about $\frac{1}{3}$d of an inch long, and about $\frac{1}{50}$th of an inch thick, and suspended them by a silk fibre, between the opposite poles of two strong magnets. By this mode of observation, he perceived that the small needles constantly turned themselves in the direction of these poles, and after some oscillations fixed themselves in that position. If he turned them very little out of this state of equilibrium, they immediately began to oscillate round it; and the oscillations which they thus performed in the presence of the magnets were evidently more rapid than when they were suspended alone in space. These small needles were therefore sensible of the influence of these magnets. The same experiments may be made with needles of gold, silver, glass, wood, and all substances whatever, whether organic or inorganic. There appears, at first sight, only two ways of accounting for these phenomena. All the substances in nature are either susceptible of magnetism, or they contain particles of iron and other magnetic metals, which communicate to them this property. But the alternative is not so inevitable as it first appears; for it supposes that the action experienced by needles is really magnetic—an opinion which cannot be positively maintained. When we see that the simple contact of heterogeneous bodies developes sensible electrical forces, the very existence of which had, for a long time, not even been conjectured, may we not consider it as possible that other circumstances may develope similar, or at least analagous forces, the effects of which could only be perceived by very delicate apparatus, and their action experienced by the small needles employed by Coulomb?—may it not be owing to some small force of this kind which is still unknown to us?

Amid this uncertainty, the best way is to observe the phenomena with accuracy, to establish their laws, and to calculate the forces necessary to produce them. This may be easily done by means of the duration of the oscillations.

Let us at first suppose that a needle, insulated in space, oscillates horizontally, in virtue of the force of torsion of a silk fibre, by which it is suspended. The statical momentum of this force may then be valued directly from the rapidity of the oscillations, and calling it n, we have $n=\frac{\pi^2 Pl^2}{3gT^2}$; where P is the weight of the needle, l the half of its length, T the time of one of the oscillations, g the force of gravity, and $\pi=3.14159$, or the ratio of the circumference to the diameter of the circle. This formula may be established in the theory of motion produced by elasticity, and will be found explained in detail under the article MECHANICS.

When the needle oscillates between the magnets, it is solicited, at the same time, by the influence which they exert upon it, and by the torsion of the fibre to which it is suspended. But if we take care to make it descend between them in such a direction, that its situation of equilibrium corresponds to the zero of the torsion of the fibre which supports it, the torsion and the attractive force will act upon it in the same manner, proportionally to the arc of its deviation, from its point of rest. This is evident for the torsion, which is always proportional to this deviation, even in great angles. But it is true also for the attractive force, in very small oscillations; for being in general proportional to the sine of the deviation, it becomes, in small oscillations, proportional to the deviation itself. If we, therefore, call Q the statical momentum of this last force, which we may suppose applied perpendicularly to the extremity of the arm of a lever equal to unity in length, $Q+n$ will be the statical momentum of the total resultant, which solicits the needle when it is placed between the two magnets. But this momentum may be deduced from the observed oscillations; for, calling their duration T′, is it also expressed by

$$\frac{\pi^2 Pl^2}{3gT'^2}.$$

We have, therefore, $Q+n=\frac{\pi^2 Pl^2}{3gT'^2}$; and, by substituting for n its value, we obtain

$$Q=\frac{\pi^2 Pl^2}{3g}\left\{\frac{1}{T'^2}-\frac{1}{T^2}\right\}.$$

Before applying this formula, it is necessary to point out some precautions, which are indispensible in performing the experiments with accuracy.

The needles must, in the first place, be preserved from the agitation of the air. For this purpose, Coulomb employed a glass receiver AA, Fig. 51, perforated at the top, and surmounted by a tube CB, the upper extremity of which was shut by a cork, which could rise and descend with facility. This cork was traversed by a rod tt of wood, or of metal, to which was attached a silk fibre, the lower extremity of which carried a ring of very fine paper, in which the small needle was placed. The glass receiver, carrying the whole apparatus, was then placed on the opposite poles of the magnets N, S. By raising, at first, the rod tt, the needle was withdrawn from the influence of the magnets;—the number of its oscillations were observed, and the direction of the zero of torsion determined. The rod was then turned till this direction coincided with the action of the magnets; and, by depressing the rod, the needle was made to descend between them.

These magnets were each formed of four bars of steel, tempered to a white heat, about 17 inches long, $\frac{3}{5}$ of an inch wide, and $\frac{1}{6}$ of an inch thick; so that each bundle was 17 inches long, one inch and $\frac{3}{8}$ wide, and $\frac{1}{3}$ of an inch thick—they were placed in the same straight line as the figure represents; so that their opposite poles N, S were distant about $\frac{8}{10}$ of an inch. After what we have demonstrated respecting the distribution of free magnetism, in bars magnetised by the method of double touch, it is obvious that the distances of their centres of action was much greater, and at least five inches; a distance which is sufficient, in order that the direction of the attractions upon the different points of the needles may be reckoned parallel.

After having established, by the aid of this apparatus, the influence of magnets upon all kinds of substances, Coulomb undertook to measure it exactly, in the case of metals which had the advantage of being easily shaped into very cylindrical needles. Messrs. Sage and Guyton having procured for him pieces that were purified with the greatest care by chemical means, he formed several needles, 7 millimetres long, and weighing 40 milligrammes, and submitted them to the action of his apparatus—All these needles, when out of the influence of the magnets, performed four oscillations in forty-four seconds, an equality which might have been expected from the similarity of their length and their weight. By taking the millimetre, therefore, as the unity of length, and the milligramme as the unity of weight, we have, for all these needles,

$$l=3.5;\ P=40;\ T=11.$$

We must also express g in millimetres, which gives

$$g=9808.8$$

These data determine the momentum n of the force of torsion of the silk fibre, by which the needles were suspended, and we obtain

$$n=0.0013551,$$

which is equivalent nearly to the effect of $\frac{1}{718}$ of a milligramme suspended to the arm of a lever one millimetre in length. When the needles were brought down between the magnets, the following results were obtained, by taking the mean of repeated experiments.

Names of the Substances.	Observed Duration of four Oscillations.	Duration of a Simple Oscillation, or T′.
Gold	22″	5″,50
Silver	20	5 ,00
Lead	18	4 ,50
Copper	22	5 ,50
Tin	19	4 ,75

From these observations, we may calculate the total momentum $Q + n$ of the forces which solicited each of the needles; and subtracting the constant value of n, we shall have Q. In this way, we obtain the following results.

Names of the Substances.	Calculated Value of $Q + n$.	Value of Q Deduced.
Gold	0.0054204	0.0040653
Silver	0.0065587	0.0052036
Lead	0 0080972	0.0067421
Copper	0.0054204	0 0040653
Tin	0.0072673	0.0059122

As the momentum of torsion alone for all the needles, is expressed by 0.0013551, we see that the action which the magnets exert upon them is about three or four times as strong as the torsion of the fibre by which they were suspended.

The remarkable differences between the value of Q for different metals, scarcely permit us to suppose, that the action experienced by the needles was that of gravitation itself, produced by the mass of the magnets; for, as gravitation acts equally upon all substances, it would have produced oscillations of equal duration. For the same reason, we cannot suppose that this action was of an electric nature. The variations of Q, indeed, correspond to a difference of three or four seconds upon the duration of four oscillations; but we cannot admit errors of this kind in the observations which Coulomb had made with great care, and had frequently repeated. It remains, therefore, to examine if the influence of the magnets could be owing to particles of iron disseminated in all bodies; and we must then determine what proportion of it these phenomena indicate.

For this purpose Coulomb formed three mixtures of white wax and iron filings in different proportions, namely,

No. 1. $\frac{1}{4}$ of the weight of wax, or $\frac{1}{5}$ of the total weight.
No. 2 $\frac{1}{8}$ of the weight of wax, or $\frac{1}{9}$ of the total weight.
No. 3 $\frac{1}{16}$ of the weight of wax, or $\frac{1}{17}$ of the total weight.

He then formed out of each of them a cylinder, 22 millimetres long, and of such a diameter, that it weighed 212 milligrammes. He suspended these three cylinders to the same silk fibre, and made them oscillate between the poles of magnets at the distance of 100 millimetres. By taking the mean of a great number of oscillations, he obtained the following results.

	Observed Duration of Forty Oscillations.
No. 1.	32
No. 2.	43
No. 3.	61

These numbers, divided by 40, will give the durations of a single oscillation, or T; by substituting them in the formula

$$n = \frac{\pi^2 P l^2}{3 g T'^2},$$

we shall obtain the total momentum, or $Q + n$, as follows:

No. 1. $Q + n = 13,4432$,
No. 2. $Q + n = 7,4450$,
No. 3. $Q + n = 3,6995$.

Coulomb did not cause the needles to oscillate out of the influence of the magnets, in order to determine the value of n, but from its value as determined in his first experiments, we may perceive that it should be excessively small compared to that of $Q + n$, and of Q, which we have actually found. By neglecting it, therefore, we may regard the number which we have obtained as representing very nearly the value of Q. This amounts to the same thing as neglecting the force of torsion of the fibre, compared to the magnetic force of the cylinders.

If we set out from the first number 13,4432, and represent by $\frac{1}{5}$ the proportion of iron filings contained in the weight of the first cylinder, which comes to the same thing as dividing it by 67,2160, we shall find by reducing the two others to the same scale, that they are respectively represented by $\frac{1}{9,005}$ and $\frac{1}{18,16}$; that is to say, by nearly the proportion of filings contained in each of the two last cylinders. Admitting, therefore, the unavoidable errors of observation, we may regard this law as correct, that is, that the forces exerted by magnets of the same weight and the same length, are proportional to the quantities of ferruginous particles which they contain, their distribution and chemical state being supposed to be the same.

The accuracy of this proportion may at first surprise us; for since the wax, like all other bodies, is influenced when placed between the magnets, the effect of this ought to enter into the general result. This is no doubt true; but it is obvious, from the first experiments, that this effect is of a different order from that which we have now observed, so that it can only have an infinitely small share in the results. Coulomb indeed had rendered it invisible, by placing the magnets at the distance of 100 millimetres, a distance at which needles of pure wax take no determinate direction.

In order to complete these first determinations, Coulomb divided each cylinder into four or five others of the same length, and by suspending them like the first, they each performed the same number of oscillations as the whole cylinder out of which they were formed; so that the action of the magnets upon each of the small cylinders was exactly proportional to their mass, a result which no doubt arose from the distance of the ferruginous particles, in consequence of which they were too slightly magnetised to act perceptibly upon each other, and to alter reciprocally their natural magnetism.

Coulomb obtained the same equality between different small cylinders of the same length, but of unequal size, formed out of a button of silver, which had been separated from the iron by simple fusion. This button had evidently preserved some ferruginous particles, for the magnets acted distinctly upon the particles which were detached from it. When it was dissolved, however, in nitric acid, and when muriate of potash was employed to precipitate it, it did not give the slightest shade of a blue colour.

In order to discover how much iron this silver contained, Coulomb compared it with the mixture of wax and iron filings, No. I. He formed a plate of it 26 millimetres long, and a cylinder of No. I. of the same length

and the same width. He then caused these two needles to oscillate between the poles of the magnets, placed at the distance of 70 millimetres, and he found the mixture No. I. to make 40 oscillations in 16″
and the silver needle 40 . . 128″

From the preceding experiments, these times ought to have remained the same, if the two cylinders had been of the same weight. The directive forces would then have been reciprocally proportional to the squares of the times of the oscillations. Consequently, *with equal weights*, the magnetic action experienced by the silver needle, was $\frac{(16)^2}{(128)^2}$, or $\frac{1}{64}$ of that which was experienced by the needle formed with the wax and the iron filings. But this last contained $\frac{1}{5}$ of its own weight of iron, and the actions of magnets are proportional to the quantity of this metal which the needles contain; consequently, the proportion of iron in the silver needle is $\frac{1}{5}$ of $\frac{1}{64}$, or $\frac{1}{320}$ of its weight, that is, 320 parts by weight, contain 319 of pure silver, and one of iron.

This result presented a term of comparison for determining the proportion of iron, which might still remain in metals purified by chemical means, that were considered as very exact, as silver, for example, when purified by cupellation, or when obtained from muriate of silver. But as needles of this kind did not experience any sensible action from the magnets when the distance of their poles was 70 millimetres, Coulomb brought them to the distance of 24 millimetres. He then formed two small needles, 15 millimetres long, one of the silver alloyed with $\frac{1}{320}$ of iron, and the other silver obtained from the muriate, and examined the number of their oscillations.

When the needles oscillated without the reach of the magnets, they performed 4 oscillations in 96″.

When they oscillated between the magnets,
The needle of pure silver performed 40 oscillations in 450″
The needle of alloyed silver 40 oscillations in 25

In the calculation of these experiments, we may suppose that the two needles had exactly the same weight. This ought to be nearly the case, since being of the same length, the torsion alone caused them to move with equal rapidity. But this supposition has no influence upon the times of the oscillation, since, from what we have above stated, the times remain the same for equal lengths, whatever be the size of the needles. Hence, by applying the formula in p. 274, the momenta Q, Q′, of the magnetic actions which they experience, will be with equal weights.

$$\text{Pure silver } Q = \frac{\pi^2 P l^2}{3g}\left[\frac{1}{(11,25)^2} - \frac{1}{(24)^2}\right] = \frac{\pi^2 P^2}{3g}.0,00616512$$

$$\left.\begin{matrix}\text{Alloyed}\\ \text{silver}\end{matrix}\right\} Q' = \frac{\pi^2 P l^2}{3g}\left[\frac{1}{(0,625)^2} - \frac{1}{(24)^2}\right] = \frac{\pi^2 P l^2}{3g}.2,558264$$

It would be of no use to calculate the factor which depends upon the length and the weight, as it is the same for both needles; and will therefore disappear by dividing the first of these values by the second: thus,

$$\frac{Q}{Q'} = \frac{1}{414,97.}$$

That is, the action of the magnets upon the silver purified by cupellation is, with equal weights, 415 times less than upon the alloyed silver. But, if we suppose that this action is exerted only upon the particles of iron, we have seen that it is exactly proportional to the quantity of this metal contained in needles of equal length. There will therefore be 415 times less iron in the pure silver than in the impure silver, and since this contains $\frac{1}{320}$ of its weight of iron, the first will contain $\frac{1}{415}$ of $\frac{1}{320}$, or $\frac{1}{132800}$, that is, out of 132800 parts, there will be 132799 of pure silver, and one of iron. These therefore are the atoms, which the most perfect chemical analysis is very far from being able to detect; and consequently, we cannot determine if the influence of magnets is here owing to this infinitely small portion of ferruginous particles. It would not at all be surprising, if so small proportions of iron should be found in all bodies, whether organized or unorganized, and even in liquids apparently the most pure. It would be very interesting, however, to try the action of magnets upon needles formed of congealed fluids; for, by taking particular care in preparing them, and even by forming each piece by chemical combination, there may be the greatest probability of excluding any mixture of iron, or at least of rendering it as little perceptible as possible, and then, if the action of the magnets upon all bodies was produced solely by the presence of this metal, it ought upon these needles to be extremely weakened, or even entirely to cease.

It appears impossible, at all events, to attribute to a similar cause the magnetic property of cobalt and nickel. I possessed a needle of nickel which had been purified with the greatest care by M. Thenard. It was 212 millimetres long, six wide, and weighed 5,178 grains. I formed a needle of steel of exactly the same dimensions, which weighed 4,586 grains. Having magnetised them both to saturation, I caused them to oscillate horizontally in the magnetic meridian. The time of ten oscillations was 87″ with the needle of nickel, and only 45½″ with the steel needle. Their shape being the same, the momenta of their directive forces were to one another directly as the weights, and inversely as the squares of these numbers, or as 0,3088 to 1; that is, the directive force of the needle of nickel, was almost one-third of that of the needle of steel. The proportion of iron which we must therefore suppose to exist in the nickel, in order to produce a similar effect, surpasses greatly the quantity which it can possibly contain; and probably the magnetic power of this metal could have been yet increased by the same means which modify the coercive force of the steel and the iron.

The method of oscillations, such as we have explained it, may be applied very usefully, both in chemistry and mineralogy, for discovering the presence and state of combination, more or less energetic, of iron in artificial productions, or even in minerals when it is found in very small proportions. It is sufficient to form needles with the substances which we wish to try, to make them oscillate between two strong magnets, and to compare their oscillations with those of a known mixture of iron in any other substance not magnetic, by means of the formulæ which we have already explained. In order to convey an idea of this kind of application, I shall give one example. Among the substances which mineralogists have arranged in one class under the name of mica, there is a great number whose chemical compositions are extremely different; and the laws of polarisation applied to these substances denote also different crystalline systems. In a memoir on this subject, printed in the first volume of the Memoirs of the Academy of Sciences for 1816, I have been led to compare two kinds of mica; one of which came from Siberia, and the other from Zinwald, in Bohemia, mixed with crystals of tin. Though the plates of these two micas were very transparent, yet the chemical tests indicated the presence of oxide of iron in very different proportions, and to a much more considerable degree in the mica of Zinwald, which, by a very exact analysis of M. Vauquelin, contained about 20 hundredths of its weight. Before proceeding to the analysis of the other mica, I thought of trying them both by magnetism. I then cut out of each of them two thin rectangular plates of similar dimensions, which I divided into smaller pieces of similar size, and joined each sort in a bundle, which I made to oscillate between two strong magnets, the bundles being suspended by a fibre, in which the torsion was insensible. I found that the bundle of mica from Zinwald performed 12 oscillations in 55″, whereas the bundle of the other mica performed only 7 in the same time. The magnetic forces of these two micas were then to one another as the squares of these numbers; that is, as 49 to 144, or as 6.8 to 20. If we therefore consider each of these actions as proportional to the quantities of the oxide of iron which they contain, which only supposes the energy of the combination to be equal, we perceive that if the mica of Zinwald contains 20 hundredths of the oxide, the other of mica ought to have 6.8. But the result of the chemical analysis, which was not sent to me till after this experiment was made, assigned precisely the same proportion. It cannot be doubted, that, in many cases, this kind of experiment may lead to curious results respecting the intensity of the combination. Its accuracy cannot be questioned after the experiments of Coulomb, of which we have already given an account, and every person will be satisfied of this who shall put it in actual practice.

The experiments described at the beginning of this article, have led us to consider the magnetic phenomena as produced by the action of two imponderable principles, which exist naturally in every infinitely small particle of iron, and of every other magnetic metal, without being able, in any case, to leave these particles and enter into another. By following out this idea with the light of experiment, we have found, that when the magnetic metals were at first strongly heated, and afterwards slowly cooled, without being submitted to the action of any magnetic body, the two magnetic principles were brought back in each particle to a state of neutrality which masked their existence. But by acting upon them in this state of indifference by the sole action of another magnetic body, we have seen that these two principles were separated by this influence in each particle, one of the two being attracted and the other repelled. We afterwards found, that in this phenomenon, the repulsion was exerted between the magnetic principles of the same name, and the attraction between principles of an opposite name, and that both of these tendencies varied reciprocally with the square of the distance; so that they are not sensible in the natural state of union of the two principles, because, in this case, the two principles act in equal quantities, and at equal distances. Guided by these laws, we have been able to measure the comparative quantity of free magnetism existing in each point of a magnetic body. By comparing these elementary forces, we have been able to deduce the direction and the intensity of their total resultant; and the efforts of this resultant, though exerting itself between magnetic principles alone, being transmitted to the material particles of magnetic bodies, in virtue of the impermeability which retains these two principles in each of them, has given us the cause, the law, and the measure of the motions which were impressed upon these bodies, when they are presented to one another after being magnetised. For all these purposes, it has not been necessary to form any conjecture respecting the physical nature of these principles; but if it should now be asked what they are, we may remark, that there exists the most complete, the most perfect, and the most intimate analogy between the laws of the two magnetic principles, and those of the two electrical principles; so that the condition, and the reciprocal actions of the magnetic bodies, are identically similar in the distribution and the law of the forces to those which are presented by non-conducting bodies, whose particles are electrified by influence, in consequence of the decomposition of their natural electricities.

But, when we study the effects of the electrical principles, in the state of separation and of liberty in which we can obtain them, we discover, by calculation, that their distribution in conducting bodies, whether free or influenced by one another, is rigorously conformable to the laws of hydrostatic equilibrium, which two material fluids obey when without sensible weight, and whose particles possess the double property of mutually repelling one another in each fluid, and attracting those of the other fluid, with an energy reciprocally proportional to the square of the distance. When we come afterwards to deduce mathematical consequences from this constitution, for those cases in which they are possible, in the actual state of analysis, we obtain, not vaguely, but rigorously, and in numbers, all the singular and minute details which are observed when electrified bodies are presented to one another at fixed or variable distances, whether we make them recede from or approach to each other, and even when they are brought so near as to produce a mutual explosion. In this last case, indeed, the excessive rapidity with which the equilibrium is restored in all the parts of those bodies submitted to experiment, a rapidity which instantly re-establishes, in each point, the new quantity of free electricity demanded by the new state of the system, and by the hydrostatical formulæ which express it; this rapidity, I say, is a new indication, by which the fluid state of the electrical principle is most strongly characterised. It appears to me, then, that in the state to which the theory of electricity has now been brought, and of which the whole honour is due to the analytical labours of M. Poisson, this theory itself, from the fidelity with which all the experiments conform to it, holds out the strongest probability that the electrical principles are really fluids constituted as it defines them; and then, from the exact resemblance which is observed between the effects of the electric and magnetic principles, in the case in which the first are subjected to a coercive force, there is the same probability that the two magnetic principles have also a similar constitution, though the independence which exists between their actions and the electric actions does not allows us to suppose them to be of the same nature as electricity.

We are now arrived at that point to which we are permitted to penetrate in the study of nature; since, by the observation of the phenomena, we have been conducted to their laws, and from these laws to the forces by which they are produced. What remains yet to be done for the phenomena of magnetism, must now depend on the perfection of mathematical analysis, and on the application of chemistry to the determination of the coercive forces by which the magnetic principles are retained in the particles of bodies; or, at least, to the investigation of the precise degree of those forces which is the most favourable for the development of magnetism. (J. B. BIOT)

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See also VARIATION *of the Needle.*

MAGNETISM, (ANIMAL), or MESMERISM, as it has been sometimes termed, from the person who principally contributed to bring it into notice, is a pretended science, which, between thirty and forty years ago, excited very considerable attention in many parts of Europe, and is still deserving of our notice, from the insight which it affords us into the nature of the human mind. The following is an outline of the history of the supposed discovery.

About the year 1777 or 1778, Mesmer, a German physician, who had already published some fanciful opinions respecting the influence of the stars on the human body, and other topics connected with astrology, broached the doctrine of the power of magnetism over the living body. Not finding his ideas to meet with that support in his native country, to which he conceived they were entitled, he repaired to Paris, then considered the centre of science and civilization, boldy relying upon the confidence of his assertions, and the credulity of the inhabitants of the French metropolis. Nor was his audacity disappointed; for he had no sooner declared his pretensions, than he met with some zealous adherents, if not among the most eminent men of letters, at least among some who possessed so much reputation as to produce a great effect upon the public mind. The object which Mesmer professed, was to cure diseases of various kinds, by a certain application of magnetism to the human body; or by exciting the magnetic influence which previously existed in it, although in a latent or insensible state. After he had resided about a year in France, he published an account of his new system, of which it will not be necessary for us to lay before our readers more than a bare outline. Some of the leading positions are as follows: Magnetism is a fluid of the greatest tensity, so as to approach to an immaterial or etherial nature, which pervades all the universe, and fills all the pores or vacancies that are not occupied by grosser matter. It is supposed to be the primary cause of many of the active properties that we observe in the universe, and especially to communicate to them the original impulses of motion and sensation. The human body is capable of receiving the magnetic influence, and the nerves appear to be the media by which it is transmitted through the different organs. This animal magnetism, when excited or liberated, is capable of being communicated from one body to another, and accumulated in them, analogous to what we have observed with respect to the electric fluid. It has, however, many peculiarities in which it differs from this agent; of which one of the most remarkable is, that it may be transported to a considerable distance, without the intervention of any other substance; and it has also the peculiarity of affecting certain individuals alone, while it has no perceptible effect upon others, a difference of constitution which can only be ascertained by actual experiment. But the most important property of animal magnetism is, its power in curing diseases, which it possesses in a degree that could not have been previously conceived, but of the actual existence of which we have the most undoubted evidence; its operation upon the body being through the medium of the nervous system, it follows that what we usually style nervous diseases, are those that come more immediately under its influence.

In proof of his hypothesis, and of the power of magnetism over the human body, Mesmer and his adherents confidently appealed to their success in the cure of diseases; and so great did this appear, and so unquestionable was the evidence on which it seemed to be founded, that, for some time, scarcely any opposition was made to it, and it was regarded as the most unreasonable scepticism to doubt of its reality. Mesmer, whether we consider him as an impostor, or an enthusiast, a point which is now perhaps not very easy to determine, did not lose the opportunity which was offered him of improving his fortune, so that, in the short space of two years, he accumulated a very large property. It was perhaps more to this circumstance than to the pure love of truth, or a genuine zeal for science, that we are indebted for the investigation which took place into the merits of the new practice. The established faculty of Paris, finding themselves completely eclipsed by this foreign empiric, made a remonstrance on the subject to the Court; and this application fortunately produced the appointment of a set of eight commissioners, of whom the most effective were five members of the Academy of Science, Bailly, Le Roy, de Boey, Lavoisier, and Franklin. This last philosopher took the lead in the inquiry, for which he was peculiarly adapted, by his acute and powerful understanding, and to him, in conjunction with his colleagues, we are indebted for one of the most valuable specimens of scientific research, that is to be met with in the history of philosophy.

The first object of the commissioners was to make themselves thoroughly acquainted with the facts; and, as the operations of animal magnetism were, at that time, solely directed to its power in curing diseases, they limited their inquiries altogether to this point. Mesmer and his pupils, encouraged by the unbounded success of their practice, had grown more confident in their pretensions, so that they now went so far as to assert, that the efficacy of animal magnetism was not confined to the nervous system, but that it acted upon every part of the animal frame; and, in fine, they supported the doctrine, that all diseases are but modifications of the same morbid condition, and that magnetism is the universal remedy, which may, with equal propriety, be applied to all of them. This bold declaration, while it seemed to strengthen the practice, in fact laid it more open to the attacks of its opponents; as, by increasing the alleged sphere of its operation, it facilitated the means of detection. Mesmer was too haughty, or too prudent, to hold any communication with the commission; but his pupil Deslon, who probably possessed more candour and more credulity, did not hesitate to disclose the mysteries of his art, and even admitted the philosophers to witness his operations. These are minutely detailed in a memoir which they published, and which was attributed to the pen of Franklin. Without proceeding to a minute detail of the manipulations, which are now universally acknowledged to be in themselves altogether unimportant, we may briefly state, that the subjects of the experiment were seated round a kind of chest, whence issued a number of iron rods, which were directed to each individual, and which might be applied to the part of the body that was intended to be more particularly subjected to the magnetic influence. The patients were connected together by a chain, and also communicated with each other by their hands, while the operator moved iron rods, or merely his fingers, in various directions before the face, or over different parts of the body of the patients: and what was deemed a still more powerful method of excitation, he occasionally pressed with considerable force upon the stomach, or the different parts of the abdomen.

After these several manipulations had been persevered in for a length of time, which, according to the effect that ensued, varied from one to three or four hours, what was called the *crisis* was produced. This consisted in some visible change, that manifested itself either in the functions or condition of the patients; some of them were thrown into convulsions; some had fits of involuntary laughter, or weeping; some uttered loud shrieks, or piercing cries; while, in others, there was the contrary state induced of stupor or coma. All these symptoms, although perfectly involuntary, still had an immediate connexion with the nervous system; but what was more remarkable, the commissioners witnessed cases in which the less equivocal effect of hæmorrhage from the lungs and the stomach was the consequence of the magnetising process. It was observed, that the subjects of the experiments were at all times under the immediate influence of the operator, so that any alteration in his gestures, or even in his looks, produced a visible change in the symptoms which were excited; at one time converting a state of stupor into violent convulsions, and at other times checking the convulsions, and inducing almost perfect insensibility. We must not omit to mentian, that an essential part of the apparatus was a pianoforte, on which different airs were played, that were occasionally accompanied by the voice, in conformity with one of Mesmer's principles, that the magnetic virtue is excited or concentrated by sound. The commissioners, in short, fully convinced themselves, that, whatever was to be regarded as the cause, the effects were really such as had been represented, and that, at least in a great majority of cases, the *crises* were actually produced upon the patients, and were not counterfeited by them in order to serve the purposes of the magnetiser.

The most interesting object of the investigation still remained, to discover upon what principle this extraordinary power acted; whether it was some physical agent, which produced a certain effect upon the whole or any part of the living body, or whether the effect was produced through the medium of the imagination. For this purpose, they determined to repeat the process of magnetising, precisely as it was performed by Mesmer, but in such a manner as to divest it of all those circumstances which might be supposed to affect the minds of the patients. Before, however, we give an account of the experiments performed by the commissioners, it may be proper to notice a few of the observations which they had previously made upon the subject. They found, by means of the magnetic needle and the electrometer, that no proper magnetism, or electricity, was actually evolved; there was no perceptible operation upon any of the senses, nor were they, as by-standers, affected in any way whatever. They observed that a majority of the patients, who experienced the most violent crises, were women, and these of an hysterical or highly excitable temperament, and generally among the most ignorant or uninformed; and it not unfrequently happened that the convulsions, or other critical changes, were induced, or at least had begun to manifest themselves, before the operator had entered upon his manipulations. These, and other analogous circumstances, necessarily impressed the minds of the philosophers with a strong conviction of what was afterwards proved by direct experiment; but they nevertheless determined to investigate the matter with the most scrupulous accuracy, and in such a manner as to leave no room for any rational doubt upon the subject.

In the first place, they allowed themselves to be magnetised by Deslon; they submitted to every part of his process, and repeated it for a sufficient number of times, but without any crisis being produced. Some of them, who were in a delicate state of health, were harassed and fatigued by remaining, for some hours together, in a state of constraint, and by the strong pressure which was made upon the stomach and abdomen, but nothing occurred in any way resembling the specific effects of animal magnetism. From these trials, they concluded that the magnetic influence has no action upon the body while in a state of health; they therefore proceeded, in the next place, to examine its effects upon individuals labouring under disease. For this purpose, a certain number of patients, that had, on former occasions, experienced the *crisis*, were removed from their usual place of exhibition to a more private situation, and were again magnetised, under the care of Deslon himself; but no persons, except the commissioners, were present, and the most perfect silence and decorum were preserved. Other individuals, labouring under similar diseases, who had not before been operated upon, were likewise magnetised; and the general result was, that Deslon's patients alone were affected, and these in a much less degree than when they had been operated upon on former occasions, surrounded, as they had been, by a number of people, who came prepared to witness some marvellous transactions, distracted by the noise and clamour which prevailed in the assembly, and having their feelings excited by a variety of circumstances, which were now carefully guarded against. And even the effects which were produced were of a very suspicious and equivocal aspect, and altogether much more resembled those that might be fairly attributed to agitation of the spirits, to fatigue, or to sympathy with the emotions that were excited in others, than to any change that was induced upon the body by a physical agent.

It was, however, determined not to rest with mere surmises or conjectures, although they might appear to be built upon the strongest foundation; and the commissioners, accordingly, proceeded to a farther set of experiments, which may be regarded as perfectly decisive. A certain number of individuals being selected, who, on former trials, were found the most susceptible of the influence, whether from the temperament of the mind or of the body, had their eyes bandaged, and were, in this state, subjected to the magnetic process. Under these circumstances, it was found that the patients were no longer able to perceive towards what part of the body the magnetic influence was particularly directed, which before had always been the case. They frequently fell into the *crisis* when the process had not been gone through; and at other times, when it had been performed, but without their being conscious of it, they did not experience the usual convulsions. There was, in short, sufficient evidence to prove, that when the patients were no longer able to see what was going forwards around them, and especially when a little artifice was employed to deceive them with respect to the proceedings of the operator, the supposed magnetic effects had no connection with the alleged cause, while they exactly corresponded to what might have been supposed to be the case, upon the supposition that the whole was referable to the influence of the imagination. We think it unnecessary to enter more into detail with respect to individual facts, or the results of particular experiments; but to those of our readers who may feel an interest in developing the operations of the human mind, and in observing the powerful influence which it exerts over the physical functions, we shall strongly recommend the perusal of the report which was published by the commissioners. They will be, at the same time, gratified by an admirable specimen of an experimental investigation, conducted in the true spirit of philosophical research, where nothing was admitted without due evidence, and where every possible objection was anticipated and removed.

A summary view of the labours of the commissioners was drawn up by Bailly, and was delivered by him, in the form of an address, to the Academy of Sciences. It concludes with the following just reflections: "Man possesses the power of acting upon his fellow-creatures, of agitating their nerves, and of even throwing them into convulsions; but this action is not to be considered as of a physical nature. We cannot perceive that it depends upon any communicated fluid; but it appears to be entirely of a moral nature, and to operate through the medium of the imagination. It is an action which is almost always productive of dangerous consequences, which can never be admitted into philosophy, and which it is useful to be acquainted with, merely for the purpose of being able to guard against its effects. Magnetism will not, however, be without its advantages to that philosophy which condemns it, as it furnishes us with an additional fact in the history of the errors of the human mind, and exhibits a most interesting example of the power of the imagination."

When the report was made public, its effect was what might naturally have been expected from it. Every one was convinced of the justness of the reasoning, and the decisive nature of the experiments; and, for some years, animal magnetism was no longer heard of, or remembered only as exhibiting a train of facts, calculated to illustrate the nature of the human frame. But ignorance and credulity are plants that take too deep root to be easily eradicated, when they have once become thoroughly established; and even when they have been, as it would appear, completely destroyed, still they spring up again, and flourish with renewed vigour. Some years after animal magnetism had been discarded, a deception of an analogous kind was imported from America, in the form of what was called the *metallic tractors*, which served to enrich the patentee, and to amuse the public mind, until the delusion was detected by the acuteness of Dr. Haygarth. His pamphlet on the tractors may be considered as a valuable appendix to the report of the commissioners, and amply confirms the general principle, that the power of the imagination in the cure of disease is almost without limits; so that, except a complete and sudden alteration of physical structure, or the restoration of lost parts, there is scarcely any change so considerable, which may not be effected through its intervention. It not only possesses an indefinite power over what are styled nervous diseases, where the primary affection consists, as far as we can judge, in some change in the action of the brain and its appendages; but even diseases of the sanguiferous system, and of the different organic functions, appear to be by no means exempted from its influence.

Of these positions, we apprehend that every individual in this country, who has any pretension to science or information, is fully convinced; but we find that in Germany, that country which is so fertile in mysticism, both physical and metaphysical, animal magnetism has still its adherents, and these not merely among the vulgar, but even among men of learning. Those of our readers who were not previously acquainted with the fact, will be not a little surprised to learn, that, in some of the German universities, so renowned for their indefatigable research and profound erudition, animal magnetism takes its place with the other sciences, and has its professors and lecturers; that journals are devoted to recording the cures that are performed by it; and that the cases stand upon the same evidence, and are received with the same degrees of confidence, with other medical facts. When we reflect that medicine is a department of knowledge which ultimately rests upon testimony, we cannot be surprised at the slow progress which it has made, at the many contradictory statements which it contains, and the retrogradations to which it is perpetually subject. We are, indeed, almost led to despair of obtaining any certain and determinate advancement in what rests upon so uncertain and fluctuating a basis, and must be so forcibly impressed with the aberrations of the human mind, as to retire from the investigation in a state of scepticism with regard to every thing except its feebleness. (α)

MAHOMET, **Mohammed**, or **Muhammed**, the celebrated Arabian impostor, was born in the year 569, and was descended from the most distinguished chiefs of the Koreish Arabs, who held the high office of guarding the Caaba, or square temple of Mecca. His father, Abdallah, was the youngest of ten sons; and, having died in early life, before he could improve his little patrimony by commerce, left his widow Amina and her child in a state of great poverty. Their whole stock is said to have consisted only of five camels, and one Ethiopian female slave. Soon after he lost his mother also, and was taken into the family of his uncle Abu-Taleb; who, as the head of the tribe, was at that time both the prince and the pontiff of Mecca, and under whose care he was well instructed in the arts both of war and commerce. He remained, however, in comparative obscurity till the age of 25, when he became factor to the widow of a wealthy trader, who rewarded his fidelity with her hand and fortune, and raised him to an equality with the first merchants in the city. He is said to have been always remarkable for the gravity of his deportment, and a strict attention to the exercises of devotion; and, after his marriage with the wealthy Kadijah, he retired every year, in the month of Ramadan, for the purpose of fasting and prayer, to a cave in Mount Kara, near Mecca. Adding the offices of charity to the profession of piety, he attracted the general respect of his fellow-citizens; and, after a period of fifteen years spent in these pious practices and solitary meditations, he either fancied himself, in his enthusiasm, really to be, or thought himself, in his hypocrisy, well entitled to assume, the character of an inspired prophet.

In the year 609, having withdrawn with his family to his favourite place of retirement, he declared that the angel Gabriel had appeared to him in the night, and commissioned him, as the apostle of God, to restore to its purity the religion of Abraham and Ishmael. His first converts were, his wife Kadijah, his slave Zeid, and his young cousin Ali; and, at the close of three years after the assumption of his prophetical office, he had only prevailed with his friend Abu-Beker and ten other citizens of Mecca, to acknowledge his mission, and to renounce the practice of idolatry.

In 612, at an entertainment given by Ali to their mutual kinsmen, he openly declared his power as an inspired prophet, and asked aloud, "Who among you will assist me to support my burden? Who among you will be my brethren and my vizier?" While the rest of his assembled friends were regarding him with astonishment and contempt, his cousin Ali, who had waited for some higher chief in the family to embrace the offer, at length exclaimed, with enthusiastic transport, "O, apostle of God, I am the man! and I will beat out the teeth, pull out the eyes, rip up the belly, and break the legs of all that oppose you." The prophet threw his arms around the neck of this fanatical proselyte, (thus proving, by his approbation of such a spirit, the earthly origin of his system,) and blessed him as his brother and his deputy. His uncle Abu-Taleb exerted all his endeavours to dissuade his son and nephew from persevering in their frantic schemes; but, in the mean time resolved to protect their persons from the rage of his tribe. Mahomet laboured, with the most persevering assiduity, to convince his countrymen of the truth of his mission, calling upon them, in his public harangues, to renounce their idolatry, for the pure, and simple, and rational belief of the divine unity; and promising his converts a future paradise of such sensual gratifications as he knew to be most suited to their character. These discourses he collected into a volume, which he called the Koran; and appealed chiefly to the excellence of its doctrine, and the beauty of its language, as proofs of its inspiration. But still the progress of his tenets was extremely slow, and the people always demanded the evidence of miracles. He affirmed his power to perform them; but alledged, that the gross unbelief of mankind would render them fruitless; and that, as the rejection of such evidence was an unpardonable offence, he would not expose them, in their present state of mind, to the hazard of committing it. While he refused, however, to work miracles, he related them; and solemnly affirmed, that he had been transported to the heaven of heavens; that, on a white beast, less than a mule, but larger than an ass, he had been conveyed from the temple of Mecca to that of Jerusalem; had successively ascended the seven heavens with his companion Gabriel, receiving and returning the salutations of the blessed inhabitants; had then proceeded alone within two bow-shots of the throne of the Almighty, where he felt a cold which pierced him to the heart, and was touched on the shoulder by the hand of God, who commanded him to pray fifty times a-day, but, by the advice of Moses, he had prevailed to have the number reduced to five; that he then descended to Jerusalem, and remounting his mysterious animal, returned to Mecca, after performing, in the tenth part of a night, a journey of thousands of years. The truth of the story was attested by Abu-Beker; and, with other marvellous tales, had no small influence on the minds of ignorant Arabs.

The Koreish tribe, however, continued to persecute his followers with the utmost animosity; and obliged many of them to flee for refuge to the king of Ethiopia. The death of Abu-Taleb, who had protected the person, while he opposed the principles, of Mahomet, left him completely exposed to the designs of his persecutors; and his uncle's successor being a declared enemy of the family, an attempt was made to exterminate the rising sect, by taking away the life of its founder. The plot having been divulged, Mahomet, and his friend Abu-Beker, made their escape during the night, while the devoted Ali, in the green robe of the prophet, took his place on the bed, and awaited, but appeased the wrath of the murderers. The two fugitives, after concealing themselves three days in a cave, made their way, by a perilous journey along the coast, to Koba, in the vicinity of Medina; and, on the following day, the imposter was carried into that city in triumph by 500 of its richest inhabitants, who had before this time become his devoted admirers.* Here he assumed the sacerdotal and regal office; and proclaimed his authority, by a new revelation from heaven, to propagate his religion by the sword, granting liberty of conscience, or rather exemption from destruction, only upon the condition of a heavy pecuniary tribute. He stimulated the courage of his followers, by preaching the strictest predestinarianism, and assuring every man of infallible safety till his appointed and unavoidable hour. He excited their cupidity, by directing the spoil (with the exception of one-fifth retained for the service of the altar) to be faithfully distributed among the soldiers. He gratified their sensuality, by giving up to their possession the female captives; and he roused their religious enthusiasm, by the assurance of a martyr's crown to every individual who should fall in battle. "The sword," he exclaimed, "is the key of heaven and of hell; a drop of blood shed in the cause of God, a night spent under arms, is of more avail than two months of fasting and prayer. Whosoever falls in battle, his sins are forgiven. At the day of judgment, his wounds shall be resplendent as vermilion, and odoriferous as musk; and the loss of his limbs shall be replaced by the wings of angels and cherubim." By these motives his armies became invincible; and, in their first encounters, were powerfully aided by his own enthusiasm or artifice. At the battle of Beder, where his troops were very inferior in number, he placed himself, with his friend Abu-Beker, on a wooden throne out of the reach of the enemy's weapons, where he prayed for the appearance of Gabriel with 3000 angels; but, at the moment when his soldiers began to droop, he mounted his horse, and casting a handful of sand in the air, rushed forward, exclaiming, "Let their faces be covered with confusion!" His words and gestures revived the enthusiasm of his troops, who shouted their war cry, and defeated the Koreish. A succeeding engagement, however, had nearly proved fatal to the life of the prophet, who was wounded in the face with a javelin, and with difficulty conveyed to a place of safety. After many struggles, in most of which Mahomet was personally concerned, a truce of ten years was made with the Koreish, which proves the weakness of his party; but having in the mean time made several converts among his late opponents, and secured the services of the Arabian tribes, he suddenly violated the treaty, surprised the city Mecca, and entered the place of his nativity as a triumphant conqueror, in the year 629. He spared the citizens, who were soon persuaded, when under his power, to profess his tenets, but destroyed the idols of the Caaba, and prohibited for ever any unbeliever to appear or dwell in Mecca. Seizing the first pretence for declaring war against the emperor Heraclius, he dispatched his troops towards Palestine, who obtained a bloody victory, or rather secured a safe retreat, after the loss of three successive leaders. His followers, partly awed by his threatened excommunications, and partly animated by their own zeal, contributed their private treasures for the prosecution of the war; and in the year 630, the prophet, clad in his green robe, and seated on his white mule, led an army of 10,000 cavalry, 20,000 infantry, and 12,000 camels, to the confines of Syria. In vain he exclaimed to his troops, when fretting and fainting under the heat of the desart, "hell is hotter." Numbers deserted his standard; and professing to have sufficiently spread the alarm of his name, but probably discovering the superior strength of the Roman emperor, he confessed that the expedition had not been directed by the angel Gabriel, and immediately retraced his steps to Medina. During the two following years he occupied himself in preaching at Medina, and in a pilgrimage to Mecca, while he dispatched his generals to carry on the work of conversion by the sword. At the age of 63 years his health rapidly declined; and he used to affirm, that he had been poisoned at Chaibar by a Jewish female. He lingered fourteen days under the influence of a bilious fever, which deprived him at intervals of the use of his reason. According to the accounts of his biographers, he publicly offered to make restitution to any person whom he could be charged with having injured; to have given freedom to his slaves, and to have waited the approach of death with the greatest firmness. But occasionally he displayed such childish impatience, as to excite the reproaches of his wife Ayesha, and used to excuse his complaints, by asserting that the acuteness of his sufferings were necessarily proportioned to the extraordinary honours with which he had been distinguished. Till the third day before his death, he regularly performed the office of public prayer; but, when no longer able for that service, he directed his faithful friend Abu-Beker, to supply his place; and this appointment was afterwards considered as a sufficient indication of his will, that the same person should be acknowledged as his successor in the regal and sacerdotal office. This arrangement is ascribed to the daughter of Abu-Beker, Ayesha, the best beloved of the prophet's wives, who prevented all intercourse between Mahomet and his early disciple and affectionate kinsman Ali;† whom she heartily hated, not only as the rival of her father, but as the detecter and discoverer of her infidelity to her husband. When the faculties of the expiring prophet became visibly impaired, he proposed to dictate a divine book as the sum and conclusion of all his revelations; but was prevented by the prudent considerations of his attendants. Still, it is said, that he spoke with the confidence of a believer in his impostures, describing the visits of the angel Gabriel, and declaring that the messenger of death was not allowed to take his soul without first receiving his own permission. Having given his consent to the request, he sunk down under the pains of dissolution; and expired with those words "O

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* This flight of Mahomet forms the Mahometan Era, called the Hegira, and took place on Friday, the 16th day of July, A. D. 622. See HEGIRA.

† Other accounts relate that Ali was incessantly watching with the most affectionate tenderness at the sick-bed of his father-in-law but, from an unwillingness to harass the expiring prophet, refused to allow any mention to be made of appointing a successor.

God, pardon my sins. I attend thee, my companion, to the realms above." He was interred at Medina, on the same spot where he expired; and his tomb is usually visited by the innumerable pilgrims to Mecca.

Mahomet is described by his followers as having been highly distinguished by beauty of person, and to have possessed a commanding figure, a penetrating eye, a flowing beard, and a kindly expression of countenance. He excelled also in all the arts of Asiatic politeness, grave and ceremonious in his general deportment, respectful to the great, affable to the poor, and full of frankness even when actuated by artifice. Though he had never been instructed in the arts of reading and writing, he excelled in the strains of eloquence and the powers of persuasion. He seems to have possessed also considerable natural talents, both for controversy and command; and is particularly celebrated for his capacious memory, and the rapid decisions of his judgment. The Koran, indeed, viewed merely as a composition, gives no great proof of understanding or genius; and being produced, not as a complete book, but in separate portions at different times, forms a motley collection of incoherent and contradictory fragments. While he uttered these occasional revelations, according as circumstances required, they were treasured in the memories of his hearers, or written by their pens on the leaves of the palm-tree, the skins of animals, or even on the shoulder-bones of sheep. A collection of these fragments, entrusted to one of his wives, was methodized by Abu-Beker into a volume; but so many errors had crept into the text, that Othman, the third Caliph, when attempting to reconcile the different manuscripts, found it an easier task to burn the whole, and to publish a new Koran for the use of the faithful. It may thus be fairly questioned, how far the boasted beauty of the style, which is held equivalent to a miracle in a prophet ignorant of letters, be in reality the pure production of Mahomet. He continued even when lord of Arabia, to preserve his usual mode of life, and even to perform the humblest menial offices, such as kindling his fire, sweeping his hearth, milking the ewes, and mending his own shoes and garments. He observed also the strictest temperance in his diet, making his ordinary repasts of barley-bread, or dates and water; delighting in milk and honey as his greatest luxuries, and abstaining entirely from the use of wine. His charity is said to have been fully attested by the exhausted state of his private purse at the time of his death; and his feelings of sympathy are considered as established, by his having frequently shed tears over his friends who fell in the field. During the life of Kadijah, he sustained no reproach on the point of conjugal fidelity; and continued as long as he lived to speak of her as his greatest benefactress. Such is the fair side of his character, and not a few of its features may, doubtless, have been necessary to maintain his reputation as a prophet. Whether his original annunciation of himself in those characters was the sudden impulse of enthusiasm, or the result of a long meditated and deep laid scheme, it may not be easy to determine; but enough is related by his most partial biographers and devoted followers to prove, that he soon ceased to be the simple devotee, or the reckless fanatic, and gave sufficient evidence of his possessing all the arts, ambition, cruelty, and licentiousness of a conqueror and a robber. He never hesitated to employ the worst passions of his followers for the advancement of his purposes; and had frequent recourse to the grossest perfidy and wanton bloodshed in the progress of his conquests. Ambition became unquestionably the ruling passion of his later years; and the means by which he sought to gain his object were not nicely balanced in the scale of morality. While he preached the duties of righteousness and compassion, he imagined, or at least acted as if he imagined, that he alone was absolved from these obligations. He indulged freely his sensual appetites, and even maintained, with the most shameless effrontery, that his devotion was increased by the aid of perfumery and lechery. His wives (who, excepting the daughter of Abu-Beker, were all widows,) did not exceed the number of eleven; but he produced a special revelation, authorising him to make the freest use of the female sex, snd even reproving him for once doubting the indulgence of heaven in his favour. See Prideaux's *Life of Mahomet;* Gibbon's *History of the Roman Empire;* Sale's *Koran;* Gagner's *Life of Mahomet;* and Mill's *History of Mahommedanism.* (*q*)

MAHRATTAS. See India.

MAIDA, Battle of. See Britain.

MAIDEN. See Guillotine.

MAIDENHEAD, is a market town of England, in Berkshire. It is situated on the banks of the Thames, which is crossed by a good bridge, and consists of one long paved street, containing very neat and excellent houses. The bridge, designed by Sir Robert Taylor, was founded in 1772. It consists of seven large semicircular arches, and cost 19,000*l.* It has a small but neat chapel, a jail for debtors and felons, and eight almshouses. Its trade consists principally in malt, meal, and timber; and, from its being situated on the great road from Oxford to London, the inhabitants derive great benefit from the passage of travellers.

The division of Maidenhead contained, in 1811, 161 inhabited houses, 165 families, and 792 inhabitants. See the *Beauties of England and Wales*, vol. i. p. 194; Lyson's *Magna Britannia;* and Maton's *Tour.*

MAIDSTONE, a town of England, and the capital of the county of Kent, is situated principally on the eastern bank of the river Medway, which is crossed by a bridge of seven arches, and consists chiefly of four streets, which meet at the market place, with some smaller ones going off from them at right angles. The High Street is wide and well built. The town is about a mile long from north to south, and three-fourths broad from east to west. The church, which is the largest in the county, is a handsome embattled building, with a lofty tower, which formerly was surmounted with a spire. The east window of it is particularly fine. The Court-Hall, in which the assizes were held, is a neat and convenient structure; the theatre is elegant and commodious; and the new buildings for the county jail, &c. are among the most splendid in the kingdom. The town is supplied with water from an enclosed spring, called Rocky-hill, by means of pipes passing under the river, which conduct it into three reservoirs. There is also a good free school here; and, within half a mile of the town, very extensive barracks have been erected by government.

Maidstone is the first hop market in the kingdom. The linen trade, first established by the refugees from the Netherlands, continues to flourish. There are many paper-mills in the neighbourhood; and, beside an extensive distillery of gin, there are several beer and porter breweries. The trade of the place is greatly promoted by the Medway, which is navigable for vessels of 50 or 60 tons, by which great quantities of timber and corn are conveyed.

In 1811, the borough of Maidstone contained—

Houses	1706 and
Inhabitants	9443

See *Beauties of England and Wales*, vol. vii. p. 1243; and Hasted's *History of Kent*.

MAIL COACHES. See Post-Office.

MAINE is a district of the United States of America, lying between North Lat. 43° 4′, and 48° 12′; and between West Long. 64° 54′, and 70° 40′. It has nearly the shape of a rhombus, having all its frontiers about 240 miles long, except the western one, which is only 160. Its mean length and breadth is about 200 miles; and it contains about 40,000 square miles, or 25,600,000 acres.

It is bounded on the north by Canada; on the east by New Brunswick, from which it is divided partly by the St. Croix, on the south and south-east by the Atlantic; and on the west by the Piscataqua about 40 miles.

Maine is divided into eight counties, as follows:—

	Population in 1811.	Principal towns.
York	41,877	York.
Cumberland	42,831	Portland.
Kennebec	32,564	Augusta.
Somerset	12,910	Norridgewoc.
Lincoln	42,992	Wiscasset.
Hancock	30,031	Castine.
Washington	7,870	Machias.
Oxford	17,630	Paris.

Total population	228,705	in 1810.
	151,719	in 1800.
	96,540	in 1790.

The general aspect of the district is elevated and uneven rather than hilly. The land ascends gradually from the coast, and is, in general, capable of cultivation. Agamenticus, an insulated mountain in York, in Lat. 43° 10′, is pretty high, and is the only one of importance.

To the west of the Androscoggin the soil is light and poor. The land between the Kennebec and the Penobscot is well adapted to tillage. This is a good grazing country, and feeds large stocks of cattle. Its principal productions are wheat, rye, barley, oats, peas, hemp, and flax. Hops grow spontaneously; and among the wild fruits are apples, plums, cherries, pears, grapes, &c.

This district is not remarkable for its trade or manufactures. It exports masts and every species of ship's timber, white pine, and oak boards, in immense quantities, and also dried cod-fish, pickled salmon, and shad. Coarse cloths, made in families, and agricultural implements, are the only manufactures of the district.

The principal towns in Maine are Portland, Bath, Wiscasset and York. Portland, built on a peninsula in Casco Bay, was incorporated in 1786. It is one of the most commercial towns in Massachusetts, and has a deep and capacious harbour, which is seldom frozen. It contains three congregational churches, viz. one Baptist, one Episcopalian, and one Quaker, an academy, built of brick, and a handsome court-house. In 1790, a light-house was erected on Portland-head, at the entrance of the harbour; and, in 1810, 42 vessels, measuring 10,726 tons, were built. The population is 7169.

Bath is a flourishing town on the west side of the Kennebec, 16 miles from the sea. It has two congregational churches, and 2491 inhabitants.

Wiscasset, on the Sheepscot, and 12 miles from the sea, has four streets running parallel with the river, and crossed by another 140 feet wide, leading to the wharf, which is 550 feet long. It has a congregational church and a court-house, and 2087 inhabitants. The river is here navigable for the largest ships.

York was settled in 1630, and called Agamenticus. It is nine miles from Portsmouth, and contains two congregational churches, and 3046 inhabitants.

Hallowell, a village 40 miles from the mouth of the Kennebec, contains 2068 inhabitants; and Augusta, three miles farther up the river, has a population of 1805.

The academies in the district are seven in number, and are all endowed with handsome grants of public lands. Bowdoin College, in Brunswick, was incorporated in 1795. The Rev. James Bowdoin left it 10,000 dollars, and his valuable library. It consists of two college edifices and one chapel.

The principal rivers here are the St. John, which is the largest; the St. Croix; the Scoodie; the Penobscot, the length of which is about 300 miles; the Kennebec, the second in point of size; the Androscoggin, a western branch of the Kennebec; the Saco; and the Piscataqua.

The principal lakes are Umbagog; Moosehead lake, about 40 miles long, and from 10 to 15 wide; and Sebacook, which, with Long Pond and Sungo River, which joins them, is about 30 miles long.

The principal minerals here are mountain and bog iron ore. A stone, which yields copperas and saltpetre, is found in Lebanon, in the county of York.

The number of congregational churches in the district is 91. Next to them the Baptists are the most numerous. Maine is an integral part of Massachusetts, and has therefore the same government.

The first attempt to settle this district was made in 1607. It was granted by Britain to Sir Ferdinand Gorges in 1635, and it was incorporated with Massachusetts in 1691, by a charter of William and Mary. See Morse's *Modern Geography*, p. 130.

MAINE and LOIRE, one of the western departments of France, derives its name from the two rivers by which it is watered. It is formed out of the Upper Anjou and the Saumarois; and is bounded on the north by the department of Mayenne and that of Sarthe, on the east by Vienne and that of the Indre and Loire, on the south by the department of La Vendée and the two Sevres, and on the west by that of the Lower Loire. It is about 26 leagues long and 21 broad, and contains about 386 square leagues, or 7637 square kilometers. The department is diversified with hills and plains, and though the pasturing of cattle is the principal object, yet it produces corn, wine, hemp, flax, and various fruits. The trade consists principally in the cloths which it manufactures. Very fine slates are obtained from the Perrieres, near Anjou.

The principal towns are—

Anjou	33,000
Saumur	9,585
Cholet	7,500
Beauges	3,003
Blaupseau	1,640
Segré	558

The forests occupy about 100 acres, of which $\frac{4}{5}$ths belong to the nation. The contributions in 1803 were 4,182,024 francs, and the population 376,033. Anjou is the capital of the department. See Anjou.

MAINE, Province of. See France.

MAINLAND of Shetland. See Shetland.

MAJOR INTERVALS, in music. Writers who correctly treat of the musical scale, and not according to the confined and mutilated state in which it is found on common-keyed instruments, having only 12 sounds in the octave, distinguish in this compass 16 principal intervals, or notes of the scale, by *numeral* designations, half of which they denominate *major* intervals, and the other half *minor* intervals, viz.

Major numerals,	I	II	III	IV	V	VI	VII	VIII
Denominators and numerators,	135	9	5	45	3	5	15	(1 & 2)
Minor numerals,	8	7	6	5	4	3	2	1

The properties of which numeral intervals are as follows, viz.

1*st*, That each major interval is complemental to a minor, whose numeral, added to its nominal, makes up *nine;* that is, the sum, in magnitude, of such a major and such minor interval, as last described, makes up an octave in each case.

2*d*, The denominators and the numerators of the *ratios*, in numbers of these complementary numerals, are reciprocals, as is shewn in the above small Table, viz. the small middle numbers are *denominators* to the major intervals above them, and *numerators* to the minor intervals below them.

3*d*, All of these are *odd* numbers, except 2 in the denominator of VIII; which exception Dr. Robert Smith has omitted to notice, when mentioning this property of major consonances, at bottom of p. 92 (2d edit.) of his "Harmonics."

4*th*, The differences, in magnitude, between minors and majors of the same numerical designation are not uniformly the same; but six of them are equal to the major first (I), or $42\Sigma+f+4m$, and two of them to the grave major first (I′), or $36\Sigma+f+3m$, as in the following table, viz.

Minor numerals,	1	2	3	4	5	6	7	8
Differences, . .	I	I	Iˋ	I	I	Iˋ	I	I
Major numerals,	I	II	III	IV	V	VI	VII	VIII

In which it is to be observed, that these grave-second differences are symetrically placed with regard to the middle and extremes of the octave.

Some incorrect writers on musical intervals have mentioned the minor second (2), or $57\Sigma+f+4m$, as occurring between major and minor intervals of the same numeral designation; others have in particular instances said, four commas (4c), or $44\Sigma+4m$; and, even in particular cases, Mr. Holder makes major and minor numerals differ only one comma, (c), or $11\Sigma+m$!

What has been said above applies to the numeral intervals only. In naming the smaller intervals, such as are enumerated in our article Logarithms *Logometric*, and a great many others equally small, no such rule, as to any constant difference between major and minor intervals, or greater or lesser intervals of the same generic name, (like *Comma*, *Difference*, *Residual*, *Fraction*, *Hyperoche*. *Diesis*, &c) has been attempted to be followed by writers, or seems indeed practicable.

MAJOR Mood, in music, called also the *Major* Key. (which see,) is that scale of intervals most generally used by composers, except when solemn and mournful subjects are to be expressed. It has a *major* third (III, or $197\Sigma+f+17m$) above its lowest or key note, instead of the *minor* third, (3, or $161\Sigma+3f+14m$,) which, in the same situation, distinguishes the Minor *Mood*, which see.

MAJORCA, Majorica, Mallorca, or Mayorca, the largest of the Iberian or Balearic islands, is situated between 39° 20′ and 40° 5′ north latitude, and between 2° 20′ and 3° 20′ east longitude, about 40 leagues distant from the coast of Spain. It is 50 leagues in circumference, and is almost wholly surrounded by a chain of mountains. There are only two small rivers in the island, one of which, named the Rierra, takes its course close by the walls of the capital. A few considerable brooks, originating in the mountains, flow through some tracts of the country; but the valleys, though fresh and fertile, are in general destitute of water. The climate is temperate; and the heats of summer are greatly moderated by the sea breezes. On the east coast the winter is very mild; but on the north, violent and destructive gales are occasionally experienced during that season of the year. The mountainous districts abound in fine quarries of variegated marble, and of different kinds of excellent stone. Slate, chalk-stone, plaster, stalactites, fossil-wood, and various calcareous mixtures, are found in several districts; but there are no evidences of what ancient geographers have related respecting its precious stones, and mines of gold and silver. In the marshes of Campos there is a quantity of natural salt, which might be worked with considerable advantage; and a warm sulphureous spring, near the same town, is used for several complaints. The island is fertile in many curious plants; but the most common of its natural vegetable productions are, capillaire, lavender, rosemary, thyme, marjoram, marsh-mallow, jonquil, and wild cellery. Mules are numerous, and, on account of the steep and rugged roads of the island, all the land carriage is effected on the backs of these animals. They are employed also in dragging heavy and clumsy carts, which are capable of holding very little loading, and which are almost a sufficient weight when empty. The oxen are small and feeble; but the sheep are large, and furnished with beautiful fleeces. The pigs, also, are large and fat, weighing from 300 to 350 pounds. Poultry is reared in considerable abundance; and game is very plentiful, consisting of hares, rabbits, snipes, thrushes, partridges, quails, &c. There are some birds of prey on the island, particularly of the hawk species, but venomous animals are little known.

The agriculture of Majorca is highly productive; and were the islanders provided with better implements of husbandry, and inclined to exert a little more industry, especially in draining the marshy grounds, might be raised to a very flourishing state. The mountains, in general, are covered with trees to the summit, among which there are numerous firs, fit for masts, and holm-oaks, of surprising growth and size. The wild olives grow vigorously on the declivities of the hills, and are singly surrounded with low walls, in order to protect them from the torrents, which often fall with great violence from the mountains. The lower grounds are often wet and marshy, with the appearance of meadows, but unfit for producing grain; but the island contains much fertile soil, which bears excellent grain, flax, figs, olives, grapes, almonds, oranges, melons, and a variety of other fruits and vegetables.

The Majorcans manufacture a strong coarse cloth for their own use, and a great quantity of corded woollen stuff, which is exported to Spain. They work also tapestry, blankets, and sashes, all of woollen, which go to Malta, Sardinia, and even America. They make several linen cloths, some of which are very fine, and coarse canvas, for the Spanish mariners. They are every year making greater progress in the culture of the mulberry and the rearing of silk-worms, and manufacture the silk for their own use. They are very expert at inlaid work, from which they derive considerable profit, and make for the Spanish market also brooms, paniers, and baskets. They have a glass-house in Palma, and a paper manufactory at Petra; but neither of them has attained any great degree of perfection. A coral fishery is carried on in the bay of Alcudia, during the months of July and August. The wines are excellent, particularly the Muscadel, Malvoisia, Pampot Roda, and, above all, the Montona. A good portion of superior brandy is distilled, both for home consumption and for commerce.

The principal exports of the island are:—

	French Livres.
Oils to England and Holland, to the value of	11,000,000
Wines to Spain and America - -	685,590
Brandy to Spain and America - -	177,000
Oranges and lemons to France - -	200,000
Almonds to France - - -	60,000
Cheese to Spain - - - -	40,000
Capers to Spain, about - - -	7,000
Beans to Spain - - - -	40,000
	12,209,590 or *L.*508,733 sterling.

The principal imports are:—

Grain, salt provisions, sugar, coffee, rice, snuff, cloth, silks, linens, hosiery, hardware, drugs, planks, powder, shot, &c. to the value of about - - - - - -	2,996,000 or *L.*124,833 sterling.

Thus leaving a commercial balance in favour of the island of about 9,213,590 French livres, 383,899*l.* sterling,) which, compared with the number of the inhabitants and the extent of territory, is not surpassed by any country in Europe.

The island of Majorca contains two cities, several small towns, and a great number of considerable villages. The cities are Palma and Alcudia. The former, which is the capital of the island, and the see of a bishop, is situated on a large bay (between Capes Blanco and Cala Figuera), which is about 3½ leagues in breadth, and contains a safe though small harbour. The city is surrounded by walls, flanked by 12 bastions, and, on the land side, is farther protected by a large dry ditch; but these fortifications are not calculated for sustaining a well-conducted siege. Some of the streets are narrow, and badly paved; but those in the lower part of the city, as well as the squares, are regular and spacious. The greater part of the houses are well built, (some of them with marble), and are chiefly in the Moorish style of architecture. The cathedral, and most of the churches, are large and handsome edifices, and the former is distinguished by its peculiarly bold and delicate spire. The episcopal palace, adjoining to it, is built of beautiful stone; and the palace royal, though ill arranged, is of great extent. The house of contraction, built in the 14th century, is one of the most remarkable edifices, and is a striking vestige of the extensive population and trade of the little kingdom of Majorca. The mansion-house attracts the attention of the traveller, by the quantity of sculpture and gothic ornaments with which it is loaded, and the portraits of the illustrious natives with which its numerous courts of justice are hung. The clock, called the Balearic clock, and sometimes the clock of the sun, but of which the history is completely unknown, is particularly deserving of notice: it marks and strikes the days and nights, according to the progress of the sun and the successive solstices, and is generally considered as the only curiosity of its kind in the world. There are several hospitals, and other charitable institutions, in the city; and the military hospital, supported by the government, contains not less than 300 beds. The population is reckoned at 33,000. Alcudia, built on a peninsula of the same name between two bays, is situated on the north-east coast of the island, about two miles from the sea. It is surrounded by old walls, of great height, and by wide dry ditches, but has fallen almost into total decay, partly from a want of good water,—and its population does not exceed 1000 persons. The principal towns are, Pollenza, containing 6000; St. Martial, 5000; Alaro, 2500; Bunola, 2600; Soler, 5000; Banalbufar, 5000; Andracio, 4000; Calvia, 1300; and a number of others, each containing about 1000 inhabitants. The whole population of the island is supposed to amount to 136,000 inhabitants, of whom about 3000, exclusive of nuns, are ecclesiastics of various descriptions.

The inhabitants of Majorca resemble the Spaniards, and particularly the Catalonians, in their general manners. People of distinction, merchants, and most persons engaged in business, speak the Castilian language; but the lower orders, and the more inland residents, use a dialect which can neither be traced nor described, but which is a strange mixture of Greek, Latin, Arabic, Catalonian, Languedocian, and Vandal words and phrases. The peasants' ordinary dress consists of a cap, jacket, wide breeches, and sometimes a loose frock; but on holidays they use the ancient Spanish costume, of a black cap, large ruff, and great hat, turned up on both sides. The citizens dress much in the same manner as those of other towns in the south of Europe. The women of all ranks dress in the same fashion, with no other distinction than what consists in the fineness of the stuffs. The head-dress, called rebozello, is neat and simple, consisting of a double handkerchief, the top of which covers the head, and is tied under the chin; then extending over the shoulders, and falling down the back half-way, the two ends meet, cross, and tie before. This part of dress, commonly made of plain or coloured India muslin, is rendered sufficiently expensive among the more wealthy by means of lace and embroidery. They wear a corset composed of whalebone, covered with black silk, sometimes adorned with silver buckles or buttons, and a petticoat, black, white, or Indian. The more wealthy have necklaces of great value, with gold crosses or handsome medallions suspended from them; and frequently also wear gold chains hanging from the corset or along the petticoat, besides watches, bracelets, and numerous rings on their fingers. When they go abroad they use a mantle, like those in Spain, and carry a fan and a long chaplet, ornamented with a gold cross and beads. They dress their feet with great neatness, and wear shoes with high heels. The women of the island have much natural elegance, and the manners of the people in general are soft and prepossessing. They are devout Catholics, without being intolerant; and, though a house of inquisition exists in the capital, there are no appearances of its being applied to any measures of persecution. The inhabitants pique themselves much on their fidelity to their sovereign, and make excellent soldiers and sailors. See Laborde's *View of Spain.* For the antiquities of this and the other Balearic isles, see MINORCA.

MAIRE, LE, STRAITS of. See FUEGO.

MAIZE. See FRANCE

MALABAR, or MALAYAVAR, the region of Mount Malaya, is a name applied to the western coast of the Indian peninsula, but varying greatly in its extent, according to different geographers.* It is sometimes applied erroneously to the whole country, from Bombay, and even from Surat, to the southern extremity, comprehending the whole of Hither India. It denotes more properly that portion of this tract, which reaches from Cape Comorin to the river Chandragiri, in North Latitude 12° 27′, including the modern subdivisions, Calicut, Cochin, and Travancore; a portion of territory, which is denominated Kerala by the Hindoo geographers, and which is expressed in this article by the designation of the Malabar coast. In a still more limited sense it signifies the province of Malabar, the most northerly of the three last mentioned subdivisions, otherwise named Calicut, bounded on the north by the province of Canara, and on the south by the Rajah of Cochin's territories.

On the Malabar coast are situated a number of opulent trading towns, the most celebrated of which are, Mangalore, Cananore, Tellicherry, Mahie, Calicut, Panana, Cranganore, Porca, Quilone, Anjengo, and Colatchee. The shelving shores afford a safe navigation; and the alternate land and sea breezes, which prevail with great regularity on the coast during the fair season, are equally favourable to vessels proceeding to the north or south. The land appears, in general, like a theatre of verdure, and presents a rich succession of cocoa-nut groves, beautiful rivers, and fruitful valleys.

The climate along the coast of Malabar is warm and rather moist, but healthful. The rainy season prevails from the middle of June to the middle of August; and the country, during that period, is liable to extensive inundations by the mountain torrents. During the months of April and May the air is remarkably dry and hot; but is daily refreshed by the regular sea breezes.

The whole line of country along the Malabar coast, besides being bounded by the sea on the west, and the Gauhts on the east, is much intersected by rivers from the mountains; and thus presented so great obstacles to invaders, that it was never subjected to any Mahommedan power, till it was attacked by Hyder Ali in 1766. The original manners and customs of the Hindoos have consequently been preserved much purer on this coast than most other parts of India. The principal casts are Brahmins, or Namboories; Nairs of various denominations; Tivees, or Tiars; and Pooleahs, or Poliars. The Brahmins are the most ignorant, and the least tolerant, of any to be found in India. They assume a much greater degree of consequence than those who inhabit the northern districts of Hindostan, keeping all inferior casts at the utmost distance, and holding strangers in utter abhorrence. A Nair may approach, but must not touch them. A Tiar must stand at the distance of 36 steps, and a Poliar at 96; and should any of these lower casts chance to touch a Brahmin, the latter must expiate the pollution thus contracted, by instantly bathing himself, and spending much time in perusing the sacred books. Nay, the Brahmins of Malabar would refuse to drink with the very Brahmins of the north; and yet, with all these apparent claims and ritual guards of sanctity, they are, in a moral sense, the most polluted and debauched wretches in the country. They are notoriously addicted to the grossest lasciviousness; and not contented with the dancing girls of the temples, who are usually reserved for their pleasure, they choose the most beautiful females of the higher tribes, who are taught to regard it as the most distinguished honour that can befal them to admit a Brahmin to their favours.—The Nairs are the pure Sudra class of Malabar, and all pretend to be soldiers by birth; but they are of various ranks and professions. The highest among them are the Kirit, or Kerum, who, on all public occasions, perform the office of cooks,—a profession which, among the Hindoos, is always a sure mark of trancendent rank, as every person may eat food prepared by one of a higher cast than himself; and he, therefore, who can presume to dress the victuals of any assembled multitude, must be one from whom no pollution can proceed. The second rank, who are more particularly called Sudras, form the militia of the country, under the government of the rajahs, and the direction of the Brahmins. To these superiors they used formerly to render the most submissive obedience; but, in their turn, exacted the respect of their inferiors with the utmost arrogance and cruelty; and hesitated not to cut down with their sabres a cultivator or fisherman, who should presume to touch their persons; or a Poliar, or Pariar, who should linger in the road on which they were passing. They all pretend to be soldiers, though they do not all follow the military profession; and are distinguished into not less than thirty distinct classes, many of whom act as husbandmen, accountants, weavers, carpenters, oil-men, &c. They are still very fond of parading up and down with their arms; and frequently assemble for tournaments, or rather for serious engagements, in presence of the higher females, on which occasions many lives are lost. They are remarkably expert in the use of the spear and large bow. They are well made and handsome in their persons, and of a fairer complexion than the inferior casts; but are thoughtless and prodigal in their dispositions, and excessively addicted to intoxicating liquors. Their peculiar object of worship is Vishnu; but they also wear the mark of Seva, or Mahadeva. Their proper duties are to speak the truth, observe chastity, bestow much charity on poor and learned Brahmins, fast and pray frequently, and perform certain ceremonies and pilgrimages. They are permitted to eat the flesh of goats, venison, fowls, and fish. Their matrimonial connections, if they can be so denominated, are precisely the reverse of all other Asiatics; and are supposed to have been arranged for the purpose of preserving their martial spirit, by freeing them from the cares of a household, and family attachments. Instead of each Nair possessing many wives, one woman is allotted to several husbands, who cohabit with her by turns, placing their arms above the door, to prevent the intrusion of another while they are in the house. Or rather, each Nair nominally marries, and partly supports, one wife, who resides in the house of her parents or of her brothers, and is at liberty to cohabit with any person whom she chooses, of an equal or higher rank with herself. She has the power of nominating the father of every child, who is thereby bound to provide for its support; but no Nair either knows his real parent, or considers his children as his heirs. His mother, or his eldest sister, takes the charge of his own household; and his property at his decease is divided among the children of his sisters.

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* The original Indian appellation is Malayalim, or the hilly country; or, according to others, is Maliabar, a name given to it by the Persians, and signifying the country of the Malays, whom they confounded with the natives of the coast of India. By the Arabs it is called Beled-ul-ful-ful, the country of pepper.

The Tivees, or Tiars, are generally cultivators, and form the great body of the Hindoo population on the Malabar coast. They are far from being of a low cast; and are a well-shaped people, of a middle stature, and date-coloured complexion. The Tetees, a lower tribe of cultivators, and Mucuas, or fishermen, are also a handsome race; and their young females, particularly, are described as extremely graceful in their persons, not very chaste before marriage, but afterwards making faithful wives and good mothers. The Mucua are an industrious tribe; and, though considered as of a very low cast, are more useful than those of higher pretensions. They are kept in a very degraded state by the Brahmins, and are not permitted to enter the temples dedicated to the greater divinities, but sometimes allowed to stand at a distance, and send in their offerings by the hands of others. Their proper deity is represented by a rude log of wood, placed in a hut, to whom they offer a cock and fruit four times a-year. They are said to have little idea of a future life, and to believe chiefly in the existence of evil spirits, who have the power of inflicting diseases and calamities.

The Poliars, or Pooleahs, are an abject and miserable race, attached as bondmen to the soil, and frequently called Churmun, or slaves. They possess neither houses nor lands, and are in a manner banished from society. They retire to solitary places, and hide themselves in ditches, or climb into thick trees for shelter. Should they meet a Brahmin or a Nair, they must cry out to give warning, till they can get out of the way; and would otherwise be cut down without ceremony, like noxious animals. When compelled by hunger to approach the villages, with the view of exchanging baskets, fruits, or other commodities, for a little grain, they make a howling noise to call the peasants; and, having made known their wants, leave the article which they propose to barter, and afterwards return to carry away what has been left in its place. They are allowed to eat of all kinds of animal food except beef Constant poverty and misery have debased their very form, and given them a squalid and savage appearance. The Niadir appear to be a branch of the same class, or even a degree lower; and many of them subsist chiefly upon land tortoises and alligators.

But even below both of these miserable tribes are the outcast Pariars, whose touch would pollute the lowest of the Poliar or Niadir race, and who are counted as occupying the utmost limit of impurity. They eat even of beef and of all kind of carrion, which, in the eye of a Hindoo, are equally forbidden and polluting. The Moplahs, or Moplays, who constitute about one-fourth part of the inhabitants of the Malabar coast, are Mahommedans, descended from the Moors and Arabs, who have settled in the country, and married Malabar women. They are the principal merchants in the country, both for foreign and home trade; and many of them are proprietors of trading vessels, which are navigated by Mahommedans, and make their voyages to the Persian and Arabian Gulfs, exchanging pepper, cassia, cardamom, cotton cloth, coir-rope, &c. for coffee, drugs, dates and dried fruits. Those among them who inhabit the coast-towns, and occupy themselves in commerce, are tolerably courteous and orderly; but such as are found in the interior are a proud, idle, worthless race, who parade about the country with their broad swords, or listlessly spend their days in a swing. They frequently break out into acts of turbulence and revenge, especially against the Nairs, who are not less proud and bigoted than themselves; and sometimes, when intoxicated with opium or bhang, openly run "a muck," attacking all whom they meet, till they are mastered and destroyed.

On the coast of Malabar are numerous communities of Jews, amounting, at the lowest calculation, to 30,000. They are divided into two distinct classes, namely, the ancient or black Jews, and the Jerusalem or white Jews. The former, the black Jews, are satisfactorily ascertained to have established themselves on the west coast of India, and in other eastern countries, long before the Christian era; but they have in general assimilated themselves so much to the custom of the places in which they reside, that they are sometimes scarcely recognisable as the descendants of Abraham. They are held in great contempt by the white Jews as a degenerate race; but, from their inland residence, they possess a greater number of ancient historical manuscripts than their white brethren on the coast, whose maritime situation has exposed their community to more frequent revolutions. In one of the synagogues of these black Jews, in the interior of Malabar, there has been found an old copy of their law, written on a roll of leather about fifty feet in length, made of goat-skins dyed red. The white Jews reside chiefly at a village called Jew's town, near the city of Cochin, and are the descendants of various colonies, who sought a refuge on the coast of Malabar after the destruction of the city of Jerusalem. They were, at their first arrival, permitted to reside at Cranganore, and were invested by the reigning prince of the country with certain privileges of nobility, and with a patriarchal jurisdiction within their own district. They possess two tablets of a metal resembling brass, on which these grants are engraven, and which bear the date of 4250 from the creation of the world, A. D. 490. After occupying Cranganore about a thousand years, and receiving frequent additions to their number by the arrival of other Jewish refugees, till, dissensions arising among themselves, one of their leaders called an Indian prince to his assistance, who destroyed and carried away the greater part of them. A few exiles collected at Cochin, where they have continued to remain, amidst various vicissitudes and sufferings*. The families of the Jews are generally stationary: but the males are continually moving from place to place for commercial purposes; and thus have a constant communication with one another in all parts of the east. The black Jews possess few of their ancient prophetical books; but have in most places the book of the Law, of Job, and of the Psalms. Among the white Jews are found all the portions of the Old Testament; and even two entire versions in Hebrew of the New Testament, one of which was made by a learned Rabbi among them, for the purpose of confuting the Christian religion. The style, according to Dr. Buchanan's account, is copious and elegant, and the translation in general accurately faithful.

At a very early period, the Christian religion also made considerable progress on the Malabar coast; which contains more persons professing that religion than any other country in India. The most ancient community are those who are called the St. Thomé or Jacobite Christians; the former derive their name from their first Bishop, Mar Thomé, which is now the official designation of every successive metropolitan; and the latter from the Apostle James, whose liturgy they profess to use. They arrived on the coast long before either the Jews or Arabs; and it has been commonly supposed that they had been driven from their own country during the persecution of Nestorius, whose opinions they were said to hold. But they appear to have had an earlier origin, and consider themselves as the descendants of the flock established by the Apostle Thomas in the East. They formerly had Bishops of the Nestorian communion, by whose adherents they may be supposed to have been sought as a refuge; but their own tenets have now been ascertained, by a communication of their Bishop to Colonel Macauley, late British resident in Travancore, to correspond in essentials with the doctrine of the Church of England. Their designation is properly "The Syrian Christians," or "The Syrian Church of Malayala;" and they acknowledge the patriarch of Antioch as their superior or head. They chiefly occupy the interior of the country north-east from Quilon, along the foot of the Ghauts, and are calculated to amount to 70,000, or 80,000. At a former period they had a king of their own; but their last sovereign, named Beliarte, dying without issue, his kingdom descended by the custom of the country to the king of Cochin†. They now consider themselves as the subjects of the Rajahs, in whose territories they reside; and their condition has been greatly ameliorated by the protection of the British authorities. Under the influence of Major Munro, resident in Travancore, a seminary has been established for the education of their youth, especially of those intended for the priesthood. Their churches are of the Saracenic architecture; and bear some resemblance to the oldest parish churches in England. They have sloping roofs, pointed-arch windows, and buttresses supporting the walls. They possess many beautiful manuscripts, and several very ancient copies of the Scriptures, in the character called the Estrangelo-Syriac; but many of their ancient books, especially those which treated of religious doctrines or church supremacy, were destroyed by the Catholic inquisitors. They use the Syro-Chaldaic language in their church service, though it is understood only by a few of their clergy; but a translation of the Scriptures into the Malayalim for their use is already far advanced. They possessed several ancient tablets of brass, on which were engraved certain privileges granted them by the princes of the country; and those tablets, though long supposed to be lost, have recently been recovered by the exertions of lieutenant-colonel Macaulay. They are six in number, and a fac-simile of the whole characters is intended to be transmitted to the learned Societies both of India and Europe. It is conjectured to form the most ancient document in existence, of the same length and preservation. They have no images in their churches, and their clergy are allowed to marry as in Protestant countries. They are a fairer race than the other natives of Malabar; and are chiefly employed as husbandmen and artisans. They bear swords, targets, and firelocks; and, being early trained to the use of the latter weapon, are said to excel as marksmen. They pay a tribute to the native princes, by whom they are greatly respected, and rank next to the Nairs; but since the Rajahs of Travancore and Cochin have subjected the smaller chiefs, these native Christians have, in common with the other classes, experienced great oppressions. Some of them are placed in very affluent circumstances; and their general character is much superior to that of the other inhabitants, especially in veracity and honesty. They are extremely attentive to their religious duties; and most of them are sufficiently educated to be able to read and write.

There are, besides, the Syrian Roman Catholics, who were constrained to join the Romish Church; but are still permitted, by a dispensation from the Pope, to perform the services of the catholic ritual in the Syro-Chaldaic language. They are described as a more ignorant and less respectable community than their primitive brethren last mentioned. There are, lastly, the Christians of the Latin Church, under the Portuguese settlement of Goa, whose communion is governed by three ecclesiastical chiefs, namely, the archbishop of Cranganore, the bishop of Cochin, and the bishop of Verapoly. The whole number of Christians of all these denominations, independent of the Dutch protestants in Cochin, is estimated to exceed 200,000.

The general dress of the natives of Malabar consists of a cotton cloth tied loosely round the waist, and reaching below the knee. Some of them wear a turban, but others merely tie the hair on the back of the head, and throw a loose piece of muslin over it. Most of the men wear in their girdle a knife and a steel pen; with which last mentioned instrument they write their accounts, letters, &c. on palmyra leaves, called *olas*. The Brahmins are always distinguished by the sacred cord on the left shoulder. The dress of the Malabar women is very similar to that of the men: their only drapery is a loose piece of muslin worn round the waist, but leaving the bosom uncovered. Their black glossy hair, tied in a knot on the top of the head, is copiously anointed with cocoa-nut oil, and perfumed with the essence of sandal wood, &c. Their ears are loaded with rings and heavy jewels, reaching almost to their shoulders. They wear a profusion of gold and silver chains, and even strings of various coins, as necklaces, with weighty bracelets, and a silver box suspended at one side, for holding areca or betel-nut, or chunam spice and betel-leaf. They are much in the practice of softening their skins with aro-

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[*] See "Notisias dos Judeos de Cochin, Mandado por Messeek Pereira de Paiva, a cuya custa se imprimirao em Amsterdam," in 4to. 5447.

[†] When Vasco de Gama visited Cochin in 1503, he saw the sceptre of the Christian king.

matic oils. They are usually barefooted, but carry in their hand an umbrella of palm-leaves, which they hold occasionally before their face as a veil. The Malabar Christians dress like the other natives, except that their women cover their bosoms. The Moplah ladies are a complete contrast in their appearance to the other females, muffling themselves up in a covering of thick cotton cloth, and always retiring upon the approach of a stranger. They are proud of their chastity, but very dirty in their persons. Except among the Nairs, the Malabar women are extremely dependent, and kept almost in a state of servitude.

The natives of Malabar generally take in the morning, before going to work, a cooling drink of water, in which a certain quantity of rice has been boiled, and continue at their labour, without intermission or refreshment, till four o'clock in the afternoon. About this time, or an hour later, they take their evening meal, retire to sleep at sun-set, and rise next morning by day-break. Their meals are short, and dispatched with silence and decorum. In taking food they employ only the right hand, as the left, being used in washing the lower parts of the body, is accounted unclean. The rice, of which their food is principally composed, is served up on a broad banana leaf; and near to it is placed an aromatic and pungent soup, made of herbs, fruits, and spices. This is poured upon the rice, which is then taken in small portions into the mouth with a spoon, or a rolled mava-leaf; but persons of a better condition use vessels of copper or brass, which they keep remarkably clean, and carefully wash after every meal. They drink nothing but water during their repasts, and pour it from the drinking vessel directly into the throat, without touching the lips. After the men have eaten, the women sit down in their turn; and when all have finished, they repair promiscuously to a river or pond, where they wash their bodies, and repeat their prayers.

The poorer classes live principally on rice, salt fish, and a coarse, but wholesome and nourishing, sugar, called *jagree*, made from the cocoa tree. Those who cannot purchase rice content themselves with an inferior grain, called *nachree*. From the despotic proceedings of the native governments, and frequent failure of the rice crops, famine is not an uncommon occurrence along the coast of Malabar; and at such times, particularly, parents are very ready to sell their children as slaves at a very low rate. This, however, is a very common practice among the lower castes at all times. Mr. Forbes mentions, that he saw a mother sell, with great indifference, a child of two years for half a rupee; and that he bought for a lady at Bombay, a boy and a girl, of eight or nine years of age, with four changes of cotton garments to each, and two months' provision of rice and salt fish for their voyage, for 20 rupees, or 50 shillings sterling.

The houses of the Nairs and higher castes are distinguished by their neatness and cleanness; and are generally built of teak wood, situated in gardens, surrounded by trees, and provided each with their own well. These houses are two stories in height, with a viranda or open hall fronting the lowest, and serving as a sitting-room. In the upper flat, called *malaga*, the natives sleep, or study, or perform any business in which they do not wish to be interrupted. The furniture consists chiefly of a few mats, earthen pots, stones for grinding, and utensils for cleaning rice, with the essential article of a swing, in which the listless proprietor passes the greater part of his time. The huts of the poorer inhabitants are constructed of mud, or of the branches of the cocoa-nut tree interwoven with each other, and are covered with leaves of the same tree, or with rushes or straw. The entrance into these habitations is low, and their interior very dark. A bed-frame covered with a mat, a kettle for boiling their food, a few flat dishes of brass or copper, an iron lamp, suspended by a chain from the roof, and a wooden mortar for pounding the rice, constitute the greater part of their furniture.

The implements of husbandry, and modes of agriculture, are of the simplest kind; but the fertility of the soil supplies the want of tillage and skill. The surface of the ground is slightly turned over with a small wooden plough. The manure commonly employed is seldom more than the straw of the last crop, which is always left of a considerable length to rot on the field. Sometimes a few leaves and slender twigs are buried in pits, to form manure; but the cow-dung is preserved as a sacred article for plastering the walls of their houses. The principal labour of the cultivator is to devise proper means for watering the fields, by means of channels from the rivers and reservoirs. Rice is the prevailing crop every where; but maize, millet, and several inferior kinds of grains, are raised on drier soils. Sesamum is sown in great quantities, for the purpose of making oil; and poppies for the produce of opium. Sugar-cane, ginger, saffron, pepper, beans, peas, &c. are regularly cultivated. In the gardens are planted figs, oranges, lemons, pomegranates, cocoa-nut, butter-palms, &c.

Gold dust is sometimes found in the Nelambur river, and other mountain torrents. Iron ore is procured in various places, and forges are erected for smelting it. In the hills of the southern districts, the iron ore is found in beds, veins, and detached masses, under a stratum of indurated clay, of which the greater part of these mountains consists; but the metallic matter is small, and the quality very inferior to that of Europe.

Horses are brought to the Malabar coast, and are very rare in the country. Buffaloes are numerous, and are used chiefly in cultivating the land; while the oxen are employed for drawing waggons, and transporting goods. The milk of the cows is used, for the most part, in its natural state, but the Malabar women occasionally make cheese, for sale to the European settlers; and the inhabitants of the Ghauts are well acquainted with the preparation of butter, which they preserve by means of salt and aromatic herbs. The native husbandmen and graziers are said to be very successful in curing the diseases of their cattle by very simple prescriptions; and their knowledge on this subject, being chiefly the result of long experience, may be deserving of attention from those who have access to their writings. Goats are reared in great numbers, and the keepers of them form a distinct caste. One species of red goats are held in great reverence as sacred animals, and are employed as necessary appendages to the principal festivals. Sheep are extremely rare on the Malabar coast; and the swine, which are found chiefly near the sea, and are fed on pilchards, do not afford a wholesome food. The dogs are of one species, of a large size, with their hair not unlike the butcher dogs of Europe, and capable of being trained to hunting. Elephants are seen among the forests of the Ghauts in large herds, and are taken in pits covered over with green boughs. Among the same mountainous and woody tracts are found the urus, wild boar, bear, tyger, large flying squirrel, pole-cat, deer, antelope.

bezoar goat, civet-cat, ichneumon, ape, jackal, and bats as large as chickens, and, according to some authors, as delicate an article of food.

Besides the common poultry, turkeys and ducks, (which last are reared in great numburs along the coast,) there are great flocks of peacocks, which occasion great damage to the gardens. The most prevailing of the wild feathered tribes are vultures, falcons, sparrow-hawks, ravens, golden thrush, parrots of innumerable varieties, blackbirds, wood-pigeons, cranes in swarms, and those singular birds resembling gross-beaks, and about the size of the European sparrow, which suspend their long nests, with their three apartments, from the extremities of the most slender branches. Among the amphibious classes, those most commonly seen on the Malabar coast are crocodiles, lizards, and otters, the first of which are extremely numerous, and often sufficiently large and ferocious to attack and carry off men, oxen, and buffaloes.

On the coast of Malabar whales are occasionally seen. The sea-swine, sword-fish, hippocampus or sea-horse, salmon, sea bream, oil fish, roach, sole, tench, pike, and mackarel, are all caught on the coast. The Indian salmon is a delicious, but very fat fish. Pilchards are taken in such immense quantities that they are often used for feeding hogs, ducks, and dogs, or even mixed with manure for the cocoa-nut trees. Oysters are very plentiful near Cochin and Collam, and are procured by divers in the same manner as the pearl-muscle. Crabs, in consequence of feeding upon certain poisonous aquatic plants, are unfit to be used as food during the summer months, particularly October and November. Tortoises are found on the coast in many places, and of a considerable size, sometimes weighing 40 pounds; but the natives do not eat their flesh, and regard them as ominous animals. Upon the death of any Malabar prince or chief, all fishing is prohibited in the vicinity, by branches of trees being stuck up at intervals along the shore or river banks; and this suspension of the poor mucua's employment continues for the space of eight or ten days, that the soul of the diseased may have time to choose, undisturbed, a new habitation in the body of a fish.

The most common of the serpents on the coast of Malabar is the coluber naja; called the beautiful snake by the natives, and the cobra de capello by the Portuguese. Its bite occasions death in a few hours, if no remedy be applied; and the most effectual application has been found to be the volatile alkali, administered in doses of 30 or 40 drops in a little water. This animal is aften tamed by the natives, who feed it with milk and sugar, and teach it various tricks. The swine and fowls devour it greedily, but are said always to leave the head untouched. There are several other poisonous snakes along the Malabar coast, especially the ringed snake, which creeps into houses, and makes its way under beds, chairs, &c.; the amphisbæna, of which the tail is as thick as the head, and hence called two-headed; and the rudhiramandali, whose bite, as its name imports, so decomposes the blood, as to make it rush through the pores of the body. The mountain snake, or boa constrictor, of a dark brown colour, is described as sometimes 30 or 40 feet in length, and as thick as the body of a well fed ox: Bartolomeo affirms that he procured one of 15 feet, and that though found only in the Ghauts, they are occasionally washed down by the winter torrents. Great attention to cleanliness, and the smoke of sulphur, or other strong smelling substances, are the most effectual means of keeping the numerous serpents of the country from entering the houses and apartments. By means of sweet-smelling herbs rubbed on the hands, and the sound of music, the natives soothe many of these snakes in such a manner as to seize them without injury, and extract their poisoned fangs.

The foreign trade of the coast of Malabar is confined, with a few exceptions, to Bombay, Guzerat, and the Persian Gulf. The exports consist chiefly of corn, cocoa-nuts, timber, rice, ghee, ginger, cardamums, pepper, sandal-wood, sapar-wood, turmeric, arrow-root, betel-nut, iron, piece-goods, &c. The total value of these exports to places beyond the limits of the Madras government, during 1811, was 2,236.718 Arcot rupees. The imports consist of alum, asafœtida, rice, sugar, cotton, piece-goods, shawls, broad-cloth, and nankeen; and their total value during 1811, from places beyond the territories of the Madras government, was 721,040 Arcot rupees.

The population of the Malabar coast has been variously estimated, according to the extent of country included under that appellation, but is universally allowed to be very considerable in proportion to its cultivated surface. Bartolomeo calculates that there are above two millions of inhabitants between Cape Illi and Tovala; which would allow about 3703 persons to every geographical square mile.

From Cape Comorin to Mount Dili, the Malayalam, or Proper Malabar, is the universal language; but the Laccadive and Maldive islands have a dialect peculiar to themselves. From Mount Dili to the neighbourhood of Goa, the Tuluvi is the language of Lower Canara. In the country around Goa, a corrupt mixture of the Canara, Tuluvi, and Mahratta languages prevails. From Goa, nearly as far north as Surat, including Bombay, Salsette, and Karanja, the language is called Kokani, a dialect of the Mahratta, with a number of foreign words intermixed. From the south border of Surat to the Rum, the Guzrattee language is the popular tongue; but in all the great cities, as Surat, Ahmedabad, Cambag, &c. the number of Mahommedans who use the Hindostanee language is very great. See Bartolomeo's *Voyage to the East Indies*; Forbes' *Oriental Memoirs*; *Asiatic Researches*, vol. v.; Hamilton's *East India Gazetteer*. (*q*)

MALABAR Proper, bounded on the south by the kingdom of Cochin, on the north by the province of Canara, on the east by the Western Ghauts, and on the west by the sea, is situated between the 10th and 13th degrees of north latitude, and may be estimated at 155 miles in length, by 35 the average breadth. The portion of this province which stretches along the coast, and about 3 miles inland, is a poor sandy soil, sometimes rising into low hills, and well adapted for the growth of the cocoa-nut tree. The more eastern division consists chiefly of low hills, with steep sides and level summits, separated by narrow valleys. The summits of these hills are commonly rocky and barren; but the sides are more productive, and frequently formed into terraces for the purposes of cultivation. The valleys are extremely fertile, and have generally a rivulet flowing through them, which carries off the superfluous water. There are numerous inlets of the sea, which intersect these lines of country, and often run a great way parallel to the coast, receiving the mountain streams, and communicating with the ocean by various narrow and shallow channels. In other places the country, beyond the low hills on the coast, is frequently overflowed in the rainy season, and, upon becoming dry, affords a favourable soil for the culture of particular kinds of rice. Towards the mountains are numerous and extensive forests. The teak tree, however, grows most abundantly about Manarghaut, and is too remote from any navigable river to be conveyed to the sea coast. The palm flourishes luxuriantly around Palighaut, and the jagory, or spirit extracted from it, is prepared in great quantities at a low rate. The few sandal trees in the province are totally devoid of smell, and the excellent wood of that name, exported from Malabar, is brought from the eastern side of the Ghauts. The principal article of European export from Malabar is black pepper; and about five-eighths of the whole produce is usually carried direct to Europe, or to Bombay and China.

The aboriginal natives of Malabar province formerly occupied detached houses, surrounded with gardens; but the foreign tribes have introduced remarkably neat villages, in which the houses are built contiguous, in a straight line, so as generally to occupy two sides of a square area, which is kept clean and free from grass. The houses are built of mud, which is of an excellent quality, and, after being neatly smoothed, is either white-washed or painted.

In some districts the labours of the field are chiefly performed by slaves, who are the absolute property of their masters, and may be sold or transferred at his pleasure, except that husband and wife cannot be disposed of separately. These poor creatures, who are of different casts, live in temporary huts, which are little better than large baskets. They are severely treated, and inadequately nourished; diminutive in stature, and squalid in appearance. A young man and his wife sell together, at six or seven guineas; and two guineas more may be added, if they have two or three children. They have one privilege above the West Indian slaves, namely, that of marrying freely any person of a similar cast; and the master of the husband has a right to the labour of the wife as long as she lives with his slave. The native breed of cattle and buffaloes in Malabar are extremely diminutive, and rarely used for the conveyance of goods, which are usually carried by porters. No horses, asses, swine, sheep, or goats, or at least a very inconsiderable number, are reared in the province; and those which the inhabitants require are brought from the eastward. No poultry ever was raised by the original natives, till the Europeans settled among them; and, still, the ducks, geese, and turkeys are to be found only on the sea coast, where they are reared by the Portuguese.

The number of inhabitants in the province is calculated to exceed 600,000; and in the southern and middle districts to average about 100 to the square mile. The inhabitants, who had for ages been accumulating the gold and silver received in exchange for the produce of their gardens, were very rich in the precious metals, when the province was invaded by Hyder Ali, in 1766; and vast sums were extorted from them by the military officers of the conqueror, as well as by the Canarese Brahmins, whom he placed over the revenue department. The province was at that time governed by a race of rajahs, who exercised in their respective districts an almost independent authority. The greater part of the lands was in the immediate possession of the Nairs. Most of these rajahs and Nairs were compelled, by the persecutions of their Mohommedan rulers, to seek a refuge in other countries; and the authority which they had possessed was transferred to the Moplahs, as the new officers and instruments of government. On the breaking out of the war between the British government in India and Tippoo sultan, in 1790, these exiled chiefs, who were leading a predatory life in the jungles, or residing in the province of Travancore, were allowed to join the British army; and, upon the termination of the war, to which they contributed little assistance, were reinstated in their possessions, with an obligation to account for the revenues. Failing, however, in their engagagements, and exercising an oppressive mode of government, they were deprived of all authority, and allowed one-fifth of their country's revenue to support their dignity. Becoming, nevertheless, refractory and rebellious, the province was added to the territories of the Madras presidency, and committed to the management of a military officer, assisted by three subordinate collectors. Since this arrangement, a great improvement has taken place in the state of the province, both as to its tranquillity and opulence; and, in 1807, the revenue, raised without difficulty, and produced by indirect taxation, amounted to six lacks and a half of star pagodas. See the preceding references. (*q*)

MALABAR Point, was formerly a spot of singular sanctity, and is still frequented by many Indian pilgrims. A ruined temple now exhibits the remains of a fine specimen of Hindoo architecture. Every stone is curiously carved with groups of human figures, animals, and other ornaments. On the top of the hill are other ruined edifices, with a few habitations of Brahmins, whose families subsist chiefly by begging from the multitude of devotees who annually visit the holy place. One of their principal objects and ceremonies is to squeeze themselves through a narrow cleft in the rock, (apparently not wide enough for the body of a child) as a sure way of expelling, or rather of expressing their sins. There is a beautiful village not far from these ruins, which is entirely inhabited by brahmins, and crowded with temples. (*q*)

MALACCA, or Malaya, a large peninsula in Asia, westward of the Gulf of Siam, and stretching south-east, from about 12° of North Latitude, almost to the equator. Its northern limits are not strictly defined; but it is at least 700 British miles in length, and 150 of medium breadth. This country is supposed by some authors to be the *Aurea Chersonesus* of the ancients, and the Ophir of Solomon. It is said that its ancient name was Sophora, or the land of gold; that the inhabitants still call their gold mines Ophirs; and that in Sumatra there is a hill of that name, probably so called by Europeans from its being rich in gold. It seems to have escaped the knowledge of Marco Polo, if it be not the country which he denominates Maletur. It has hitherto been considered as the original seat of the Malays, and hence by Europeans is always called Malaya, or Malacca; but Mr. Marsden has now ascertained, that its present possessors were adventurers from Sumatra, who formed a settlement on the peninsula about the middle of the 12th century; and that the indigenous inhabitants, who were gradually driven into the central woods and mountains, are an entirely different race of people, nearly approaching in their physical character to the Negroes of Africa.* Under a leader named Sri Turi Buwana, they emigrated, about the year 1160, to the south-eastern extremity of the peninsula, named Ujong Tanah, where they were at first distinguished by the appellation of Orang de bawah Angin, or the Leeward people; but, in process of time, the coast became generally known by the name of Tanah Malayo, or the Malayan land. In this situation they built their first city, which they called Singapura; and their rising importance soon excited the jealousy of the kings of Maja-pahit, a powerful state in the island of Java. Their fifth king, Sri-Iscander Shah, withstood for several years all the efforts of these powerful enemies; but at length, in 1252, he retired first to the northward, and afterwards to the western coast of the peninsula, where he founded a new city, which he named Malaka, from a fruit tree of that name, (*Myrabolanum*) which grew in great abundance on the adjoining hill. Here he reigned 22 years with great reputation, and raised the city to a state of considerable importance. His successor, Sultan Magat, reigned only two years, and died in 1276. To this period the Malayan princes had been worshippers of Brahma; and Sultan Muhammed Shah, who now ascended the throne, was the first Mahometan sovereign. He acquired great celebrity during a reign of 59 years, by the zealous propagation of his faith, and extended his influence over the greater part of the west coast of the peninsula, which now received the appellation of Malayo. His son, after a short reign, was murdered in 1334 by the king of Arrakan, with whose family he had contracted an alliance; but his successor, Sultan Modafar Shah, was distinguished by the wisdom of his government, and left a book of laws, which, to this day, is held in high estimation. About the year 1340 the king of Siam, becoming jealous of the growing power of Malaka, invaded the country, and laid siege to the capital. His armies were at that time defeated by the general of Modafar; but there is reason to believe, that, about the end of the 15th century, the kingdom of Malacca was for some time subject to the Siamese. Sultan Mahmud Shah, the 12th Malayan king, and the seventh and last king of Malaka, recovered the independence of his country in 1509; but was soon after obliged to yield his capital to the more powerful arm of the Portuguese. With the principal inhabitants of the city he retired to the neighbourhood of the first Malayan establishment at the extremity of the peninsula, and founded the city of Johor, which still subsists as the metropolis of a separate kingdom. But the predominating influence of the European powers, who have successively held possessions in the country, has prevented any of the petty states, into which the peninsula is now divided, from attaining any considerable importance. The peninsula is at present inhabited by several distinct races of people. The Siamese possess the northern portion to the 7° of north latitude, extending from the east to the west side. The Malays occupy the whole of the sea coast on both sides, from that point of latitude to Cape Romania; but, in some places, are mixed with the Bugis from Celebes, who have still a small settlement at Salangor. The inland parts towards the north are inhabited by the Patani people, who are supposed to be a mixture of Siamese and Malays, and possess independent villages. Among the central forests and mountains are found tribes of Caffres, resembling those of Africa in every respect, except in stature, few of them exceeding four feet eight inches in height. By the Malays, these people are called Samang; and such of them as reside in the neighbourhood of the maritime states have borrowed some slender portion of civilization; but those who occupy the mountains are still in the lowest stage of savage existence. The former have fixed habitations, plant a small quantity of rice, and barter with the Malays for food or clothing, the resin, bees-wax and honey of their native forests. The latter are divided into petty communities, perpetually at variance with each other; and wander naked through the thick forests in quest of roots or game, sheltering themselves from the weather under the first tree or thicket.

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* To the article Sumatra, therefore, we refer our account of the Malay race, as having probably originated there, and as their state and manners in that island are best known.

The coasts of Malacca are, for the most part, flat, marshy, very insalubrious, and many rich and beautiful plains are left in a great measure uncultivated; but the finest productions of nature are here brought to maturity without the aid of human culture, and the country is covered with odoriferous woods, and innumerable flowers of the most delightful fragrance. The chief agricultural produce is rice, and the little cultivation given to the fields is performed by the hands of slaves, or by means of buffaloes. In the northern regions, particularly in the territories of Patani, considerable numbers of cattle are reared, of which the Portuguese are said to have imported annually 1500 head into their settlement at Malacca. The inland tracts are covered with forests, inhabited by elephants, tygers, wild boars, monkies, civet-cats, ouran-outangs, and a great variety of curious birds. Gold dust is found in some of the rivers; but the principal productions of the country, and articles of its trade, are pepper and other spices, gums, odoriferous woods, timber, tin, and elephant's teeth. The peninsula is divided into a number of petty states, which are always at war with each other, or engaged in pillaging the neighbouring coasts and islands. These states are governed in a manner resembling the old feudal system of Europe. The head of the state is a rajah, who usually assumes the name of sultan, introduced by the Arabs; and under him are a certain number of dattoos, or nobles, who have each a train of subordinate vassals. The people are slaves to their chiefs; but the chiefs are sufficiently turbulent and independent in regard to their kings or sultans, whose commands they obey or not, as it may suit their interest and pleasure. On the east coast are the states of Ligor, Patani, Trangano, Packang, and Johor; and, on the west, Rumbo, Salangor, Perak, and Queda; but little authentic information has yet been procured respecting their internal condition. Ligor is a place of no importance; and the chief productions of its territories are tin and ivory. Patani is a small town, in 7° north latitude, at the bottom of a gulf, frequented by numerous and ferocious pirates. Trangano is a small trading town, pleasantly situated amidst low hills, covered with fruit trees; and producing much pepper from its territories. Packang, about 60 leagues north from Cape Romania, is a place of little consequence, and its houses are chiefly built of reeds and straw; but the streets are bordered by trees, which give the town the appearance of a collection of gardens. Johor, at the south promontory of the peninsula, was formerly a large and well built town; but was destroyed by the Portuguese in 1608. Its neighbouring territory furnishes cinnamon, pepper, fruits, and ivory. Rumbo, an inland kingdom, about 60 miles eastward of Malacca, may be regarded as the most ancient of the Malay states in the peninsula, still possessing the original written commissions from the parent government of Menangkabau, in Sumatra, and retaining a peculiar dialect, which distinguishes them from the other natives. Perak abounds in tin, and was occupied by the Dutch while they held Malacca. Queda, a maritime province of considerable extent, is more known than any other of the western states, especially the town of that name, in 6° of north latitude, on a river about 300 yards, and navigable by vessels of 300 tons. The inhabitants are principally Malays of the worst description, inured to murder, and addicted to the vilest passions; but the right side of the river is inhabited by Siamese, Chinese, and a few Roman Catholic Christians. About four or five leagues up the river is a mean looking town, called Allessaar, where the king resides in a palace resembling a spacious farm-house and yard, with several low buildings attached to it, containing his haram; and whose chief dignity seems to consist in the number of his wives. Nearly one half of the inhabitants of this place are Chinese, who have a large temple, which forms the most striking object in the town. The west coast, and the southern extremity of the peninsula, are studded with islands, which are situated close to each other, and separated from the main land by very narrow straits; but, on the eastern side, the sea is more open and less interrupted. The principal islands are, Prince of Wales' Island, Pulo-Penang, Sincapoor, Batang, Bintang, besides an almost nameless multitude of smaller islets clustered together. The population along the Malay coasts is not supposed to be making much increase, nor are the marriages prolific; and even under favourable circumstances, the average number of living children in a family is not rated above two. The piracies and depredations of the Malays along their coasts, have been considerably repressed by the predominance of European naval powers in the eastern seas; but the authority of law and justice is still very imperfectly established among them; and trading vessels still require to be armed, and to use every precaution against a surprise. Ships returning to the ports of Hindostan from their eastward voyages, frequently touch at Salengore, Prince of Wales' Island, and Queda, to collect tin, pepper, betel nut, wax, elephant's teeth, and rattans; for which the principal article of exchange is always opium. See Marsden's *History of Sumatra;* Haensel's *Account of the Nicobar Islands;* and Hamilton's *East India Gazetteer.* (*q*)

MALACCA, (THE TOWN OF,) of which the origin and early history has been briefly noticed in the preceding article, is situated on the south-west coast of the peninsula, in 2° 12′ of North Latitude, and 102° 2′ 15″ of East Longitude. When taken by the Portuguese in 1509, it is said to have extended along the shore about three miles, and to have been divided by a river into two parts, which were joined by a bridge. The mosque and palace were built of stone, but the other houses of wood. While it was in the possession of the Portuguese, it was repeatedly attacked by the kings of Acheen; and at length, with the aid of these Sumatrians, was taken by the Dutch in 1641. It gradually declined after it fell into their hands; and their whole establishment, civil and military, seldom exceeded 500 men. It was taken by the British in 1795, restored at the peace of Amiens, but re-captured in 1807. Its fortifications have been suffered to fall completely into decay. The town is situated close to the sea shore; and there is a small fort, which formerly commanded the landing place, but is now of little service. It is divided from the town by a small river, over which is a draw-bridge; and within its walls is the residence of the governor, and of most of the British inhabitants. On the top of a small hill, in the middle of the fort, are the ruins of the old Dutch church; and another of more recent origin, built at the side of the hill, is also in a state of decay. The town itself is neither large nor handsome. The streets are very narrow, and the roads very sandy. There is a brick pavement before some of the best houses; but being crossed at the end of every house by a wall, it is of no service to passengers. The best houses are large and commodious, but far from handsome, and are built with thin walls of brick or stone. The lower floors are paved with square bricks, and not matted; but the upper floors are made of boards, and the sloping roofs covered with pan-tiles. The windows are of rattan, with shutters which fold back against the wall. The houses of the poorer classes are constructed of wood, and thatched with the leaves of the cocoa-nut; while some of the poorest live in huts of bamboo and palm leaves. The principal inhabitants have garden houses, about a mile or two from the town, which they visit in the morning and evening; and, besides these, have also country seats about twenty miles inland, to which they retire in the fruit season for several weeks to enjoy the produce of their orchards. The principal fruits of Malacca are shaddocks of an inferior kind, pine apples and plantains superior to those of Bengal, and particularly the delicious mangostean. There are no British among the inhabitants, except those who are employed in the service of government, and only a few Dutch who are natives of Holland; but the descendants of Europeans, especially of the Portuguese, are numerous. The Malay population is considerable; and the number of Chinese in the town and suburbs is estimated at six thousand. The Chinese are the principal mechanics in the place, as the Malays are too indolent to practise any laborious arts. They are also the most industrious cultivators of the ground; and have many plantations of sugar cane and culinary vegetables in the suburbs. The principal manufactures, are arms, cutlery, coarse cloth worn by the Malays, and cordage made sometimes of the cocoa-nut fibres, but most commonly of the cane. The trade of Malacca is very trifling, (having been superseded by Prince of Wales' island, both as a place of commerce and of refreshment.) and European and Chinese articles bear nearly the same price as they do in Bengal. The export trade principally consisted of all the produce of the straits and eastern ports, such as tin, pepper, biche de mar, sago, rattans, canes, elephant's teeth, and some gold dust. The country ships from Calcutta to the Malay coast bring opium, piece-goods, silks, and dollars. During the Dutch government, the opium was bought on their East India Company's account by the governor, who, with the fiscal and skahbunder, were the principal merchants.

All classes of the inhabitants are subject to the Dutch laws, which are administered by a fiscal, who acts as judge both in civil and criminal cases; but in causes of importance, there is a jury of seven persons empannelled, and the proceedings of the court are submitted to the inspection of the governor. Criminals are now executed by hanging, but formerly, and even since the place came into the possession of the British, slaves were executed by being broken on the rack; but when Lord Minto touched at Malacca, on his way to Java, he commanded the instrument of torture to be broken to pieces. There is a Portuguese Church, with two or three priests, in Malacca; and an English school, kept by a native of Bengal; but the opulent Dutch residents send their children to be educated in Calcutta. The garrison consists of a battalion of Bengal sepoys, and a company of Bengal native artillery. The jurisdiction of the British government extends about 50 or 60 miles inland; and the river, which runs through the town, is navigable nearly to the same distance, but no attempts have been made to explore the interior to a greater extent.

The lower classes in Malacca subsist chiefly on rice and fish, both of which may be procured at a moderate price and of excellent quality. In addition to these, the higher classes use poultry and salt provisions, which last article they purchase from the ships that arrive at their port. Cows are very rare in the place, and are kept only by a few private families for the sake of the milk; but the buffalo, while it performs the labour of the ox, supplies also the place of the cow, and affords milk and butter of an inferior quality. There is a small and spirited breed of horses, resembling those of Acheen, which are usually sold at 50 dollars each; and these, with buggies and palankeen carriages, or sometimes chairs borne by slaves, are the usual modes of travelling and making visits. Among the curiosities of Malacca may be noticed the Chinese burying ground, which covers a large hill about two miles from the town. The graves are lined and arched with brick, and a small space around each is enclosed by a wall about half-a-yard high, resembling the form of the capital Greek Omega. The entrance corresponds with the opening. At the bottom of the letter, and at the end of the grave nearest to this opening, a small grave-stone is erected, on which written characters are inscribed. See Hamilton's *East India Gazetteer*; and the *Baptist Missionary Accounts*. (*q*)

MALAGA*, an ancient and opulent town of Spain, in the province of Grenada, about 235 miles south of Madrid, is situated in 36° 43′ 30″ of north latitude, and 40° 25′ 2″ of west longitude. It stands at the foot of a ridge of hills at the termination of a beautiful plain, about eight miles in breadth, and makes a fine appearance at a distance; but will not bear a near inspection. The streets, as in other Moorish towns, are very narrow; and each house, containing a court in its centre into which the windows open, is generally large. There is only one square in the town, (and that is neither spacious nor handsome;) and the churches and convents are so crowded among the houses, that whatever beauty they possess is nearly concealed. The Alameyda is the only part of the town which is handsome; and is indeed described as truly magnificent. It consists of a foot-walk in the middle, about 80 feet wide, with orange and oleander trees planted on each side. On the outside of these are good carriage roads, and on both sides a row of splendid and elegant houses. At the end of this walk is placed a fine marble fountain, consisting of three basins, ranged above each other, and gradually diminising in size. From the lower basin rises a column, supported by beautiful female figures, on which the second basin rests; and the third is raised on a similar column, supported by other groups of figures, in a state of nudity not altogether consistent with decency. On the side of a hill, communicating with the city, stands an ancient castle in good preservation, called Gibralfaro, or the hill of the lighthouse, but now called the hill of St. Christopher. From many Roman inscriptions found in the place, it is ascertained that this fortress was the site of a Roman temple and castle, but the present structure is entirely the work of the Moors. It completely commands the city; and, by the modern art of fortification, might be rendered impregnable. There is another Moorish building in considerable preservation, which was formerly a kind of dock for the protection of the galleys, but is now converted into storehouses. The Alcasaba, an Arabian palace near the shore, has been partly destroyed, and its place occupied by the new custom-house, which is a fine building in the pure Spanish style. The Cathedral, said to be as large as St. Paul's in London, is a fine object; and is a mixture of the Roman and Gothic styles, on the model of that of Granada, and founded in 1529. The interior is finished in exquisite style; and presents an oblong spheroid with a row of Corinthian pillars, around which is the nave. These pillars support a lofty roof of well turned arches, with the sky painted in the compartments. The high altar and the pulpit are of beautiful flesh-coloured marble; and the choir is so singularly fine, that it has been called the eighth wonder of the world. It contains above 50 stalls curiously carved in cedar and mahogany; and a considerable number of statues of saints by the celebrated Alonzo Cano, and his pupil, Pedro de Mena: There are a few marble monuments in the church, particularly one erected to the memory of a late Bishop, Josse de Molina, who expended upon the edifice a sum equal to about 20,000*l*. The best of the paintings, (which are inferior to those of Seville,) is one by Cano, representing the virgin in heaven with the infant Jesus in her arms, and a group of angels in the act of adoration. There are two fine organs in this Cathedral, the pipes of which, instead of being perpendicular, project from the instrument, terminating like the large end of a trumpet, so as to resemble a range of trumpets over the top of the choir, gradually diminishing in length. The church within the walls is 400 feet in length, 260 in breadth, and, from the floor to the arches, 140 in height. The population of Malaga, before the year 1804, amounted to about 75,000; but thousands were swept away in that fatal year by the epidemic fever which prevailed along the coasts of the Mediterranean; and, after the disorder had nearly ceased, the surviving inhabitants were found to amount only to 52,376.

The port of Malaga is not large, but is one of the best artificial harbours in the world, and affords sufficient depth of water for a ship of the line to lie close to the pier. The commerce of this town is considerable, and the greater part of its exports are the produce of its own fertile soil and benignant climate. Upon the banks of the rivers Guadalmedina and Guadalorce, which flow through the richest valleys in the world, a prodigious quantity of figs, almonds, oranges, lemons, olives, sumach, juniper berries, wax, and honey, are raised; which, with dried raisins, wines, and cork-wood, form the native and regular articles of trade. Coffee, cotton, cocoa, indigo, and pimento, were all cultivated in the adjoining countries many ages before America was discovered; and have been increased so much of late years, as almost to render it probable that this part of Spain might supply all the articles hitherto furnished by the West India Islands. Sugar has been raised in the vicinity for at least 700 years back, and the whole progress of planting and manufacture has undergone little improvement during the whole of that time. The sugar made on this coast resembles that of Cuba, and might be sold at a lower rate than those of an equal quality from the West Indies. The plantations of cotton and sugar-cane are dug with all the neatness of an English garden; and in their culture great use is made of irrigation. Wheat and barley alternately, without either manure or fallow, are raised on the fine level sandy plains along the coast. Several manufactured articles are here prepared for exportation. The flax and hemp, which are remarkably good, are made into linen and sail cloth for the colonies; and the silk is manufactured into satins, velvets, taffetas, ribbons, and silk stockings, both for home consumption and exportation. There are also some small manufactories of paper, leather, soap, hats, tapes, and woollen cloths. Eleven parts in twelve of the exports of Malaga, in short, consist of its native productions, and always exceed the imports. Hence the trade of this city, though inferior to that of Cadiz, is, in proportion, more beneficial to the city; and, in point of commercial consequences, it ranks as the third port in Spain, after Cadiz and Barcelona. For a long period, wine has been the principal article of exportation; but cotton has recently become a greater object of culture in the adjoining country, and may in time form a valuable part of the exported produce. There is a regular intercourse in times of peace, and much commercial smuggling during war, between Malaga and Gibraltar; and it is probably from these causes that the inhabitants are always friendly towards the British nation. See Jacob's *Travels in Spain*, and Semple's *Second Journey in Spain*. (*g*)

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* The name is said to be derived from a Phenician word signifying *to salt*, as originally founded for the purpose of curing the fish caught on the coast; and it appears, from inscriptions which have been dug up, that, in the time of the Romans, a company of merchants in the place enjoyed a monopoly of salting fish.

MALDIVES, or Maldivian Islands, that is, "the Isles of Malaya," are situated between the equinoctial line and the 8° of North Lat. They are divided into several clusters, called Atollons, most of which are circular; but some are oval, and separated from each other by narrow channels. Each of these clusters is environed by rocks, which defend them from the uncommon fury of the surrounding sea; and most of the islands of which they are composed are little more than rocky shoals or sand banks, which are flooded at spring tides. The larger islands are inhabited and cultivated, but have never been completely explored. The French East India Company had formerly a party of soldiers resident on the islands, but these were removed by M. Lally in 1759. A few vessels from the British settlements in India used to visit the Maldives for the purchase of cowries; but the unhealthiness of the climate, and the delays experienced in the procuring of their cargoes, have occasioned this trade to be abandoned by Europeans. It is still carried on, however, by Maldivian boats, which generally arrive at Balasore, at the mouth of the Calcutta river, in the months of June and July, loaded with cowries, salt-fish, turtle-shells, and the various produce of the cocoa nut tree: and usually set sail, on their return, about the middle of December, with cargoes, consisting principally of rice, with sugar, hardware, broad cloth, silk stuffs, coarse cottons, tobacco, &c. Their imports to Bengal, in 1810, averaged about 184.129, and their exports 90.182 sicca rupees. They send vessels annually also to Acheen with dried bonetto; and sell dried shark-fins, for the China market, to the ships which occasionally visit them. They carry on a busy traffic among themselves, as the different clusters are occupied by their own peculiar dealers and artisans, one by weavers, another by gold-smiths, another by potters, joiners, mat-makers, &c The traders go from island to island in boats with a small deck, generally carrying their male children with them, and frequently occupying a twelvemonth in their voyage. They are described as a mild and inoffensive race; and Europeans wrecked on their coasts have experienced the kindest treatment from the chiefs and their subjects. Little is known respecting their internal government; but there is no appearance of wars among the inhabitants of the different groups. They profess the Mohommedan religion; but, in some of their customs, resemble the Boadjoos of Borneo. One of their annual ceremonies is to launch a small vessel, loaded with perfumes, gums, and odoriferous flowers, which is set adrift at the mercy of the winds and waves, as an offering to the spirit of the winds; and sometimes similar offerings are made to the spirit whom they call king of the sea. (*g*)

MALDON, or Malden, an ancient burgh and market town of England, in the county of Essex. It is situated on the declivity of an eminence south-west of the estuary of the Blackwater, and consists principally of one street stretching about a mile from east to west, crossed by a smaller street. Many of the houses are modern and excellent. The church of All-Saints is an ancient and large building, with a square tower, surmounted by a spire, like an equilateral triangle. St. Mary's Church is a spacious edifice, situated on the lower part of the town, founded in 1056. St. Peter's, now united to All Saints, has only its tower remaining; but there is attached to it a building erected by Archdeacon Plume, for a grammar school and library, consisting of his own collection. The town hall, situated near All-Saints Church, is a large and ancient brick building. An extensive range of barracks has been erected by government near the west end of the town. The foreign trade of Maldon is chiefly to the East, whence it imports iron, deals, corn, tar, &c. Its coasting trade consists of coals and corn, of which last great quantities are annually sent to London. As the river has only eight feet of water at spring tides, vessels of large burthen are obliged to lie a little way below the town, so that a number of lighters are kept in constant employment. The burgh is governed by two bailiffs, chosen annually, six aldermen, and 18 capital burgesses. The number of electors who choose the two members of Parliament is about 200. There was formerly a Carmelite priory and an hospital for lepers in this town. Several antiquarians have supposed Maldon to be the ancient *Camelodunum*.

In 1811 the borough contained 505 houses and 2679 inhabitants. See the *Beauties of England and Wales*, vol. v. p. 274; and Morant's *History of Antiquities of Essex*.

MALEBRANCHE, Nicholas, an eminent French philosopher, was born at Paris, in the year 1638. Being naturally of a delicate constitution, he received the rudiments of his education at home, under the care of a domestic tutor; and he afterwards prosecuted his studies at the college of La Marche, and at the Sorbonne. At the age of twenty-two he resolved to embrace the monastic life, and was admitted into the congregation of the oratory in 1660. He first directed his attention to the study of the oriental languages, and of ecclesiastical history; but having accidentally met with Des Cartes' treatise *On Man*, he, from that period, devoted himself entirely to metaphysical speculations After a long study of the Cartesian philosophy, he wrote his celebrated treatise *De la Recherche de la Verité*, which was first published in 1673, in three volumes 12mo. In this work, which is written with great ingenuity and elegance, the author points out, with much acuteness, the causes of error that arise from the disorders of the imagination and the passions, and from an implicit confidence in the senses. He explains the nature of memory, and the association of ideas; and discovers the sources of error in the theories of the scholastic philosophers. Although a professed disciple of Des Cartes, he has many original thoughts; and he developes several of the metaphysical ideas of his master with great clearness and ingenuity. He denied the influence of external objects on the mind, as well as the power of the mind to produce ideas of itself. Hence he was led to ascribe their production immediately to God; and thus he arrived at the great principle of his system, that the human mind immediately perceives God, and sees all things in him. The elegance of his diction, and the ingenuity of his reasonings, rendered the system of Malebranche extremely popular, notwithstanding its mystical tendency, and procured him a numerous train of followers; but his works are now read chiefly on account of the language, and of the fine reflections which they contain.

Besides the work we have just mentioned, Malebranche published several other treatises, principally with the view of illustrating, confirming, and vindicating the doctrines contained in his *Recherche*. In the year 1699, he was admitted an honorary member of the Academy of Sciences; and several papers of his were inserted in the Memoirs of that body. Notwithstanding the delicacy of his constitution, he enjoyed pretty good health, till near the period of his death, which took place in 1715, when he had attained the age of seventy-seven.

In private life, the manners of Malebranche were simple, modest, cheerful, and complaisant. From the time he became acquainted with the writings of Des Cartes, he devoted himself entirely to solitary contemplation, with a view to enlighten his mind by the discovery of truth. He despised what is commonly called erudition, and had so little taste for poetry, that he could never read ten verses without disgust.

The following are the principal works of Malebranche.

De la Recherche de la Verité, first published in 1673, and afterwards, with considerable alterations and additions, in 1712, in two vols. 4to. and four vols. 12mo.

Defence de l'auteur de la Recherche de la Verité, &c. Rotterdam, 1684, 12mo.

Traité de la Nature et de la Grace, 1680.

Lettres, dans lesquelles il répond aux Reflexions de M Arnauld, &c.

Traitè de Morale. Essais nouveaux de Morale, &c.

Entretiens sur la métaphysique et sur la Religion, 1676.

MALESHERBES, CHRISTIAN-WILLIAM DE LAMOIGNON DE, the son of the chancellor of France, William de Lamoignon, who was descended of an illustrious family, was born at Paris, in the year 1721. He acquired his early education at the Jesuits' College, and afterwards devoted himself to the study of the law, history, and political economy. At the age of twenty-four, he was appointed a counsellor in the parliament of Paris; and in 1750, he succeeded his father as president of the Court of Aids. Along with that office, he also became superintendant of the press; and in this situation he found means to promote liberal inquiry to a degree beyond all former example in that country. It was through his favour that the French Encyclopædia, the works of Rousseau, and several other speculative writings, issued from the press. The superintendence, however, was afterwards taken from him, and conferred upon Maupeou, under whose auspices the former rigorous inquisition into literary productions was renewed.

Malesherbes now devoted himself to the duties of his office as president of the Court of Aids, and resolutely opposed every encroachment of arbitrary power. When the proceedings of this court were to be prohibited, in consequence of the spirited conduct of the president, in the case of one Monnerat, who had been treated with great injustice by the farmers of the revenue, Malesherbes took occasion to present a remonstrance to the king, protesting, in the strongest terms, against the enormous abuse of *lettres de cachet*. Soon after, Malesherbes was himself banished to his country seat by a *lettre de cachet*; and the tribunal over which he presided was abolished by the Duke de Richelieu, at the head of an armed force.

During his retirement, his time was occupied with his family, his books, and the cultivation of his grounds. He committed to paper a variety of observations on the political and judicial establishments of France, and on agriculture and natural history, which all perished amidst the revolutionary troubles. On the accession of Louis XVI. he was recalled to the exercise of his public functions, and resumed his situation as president of the restored tribunal. Upon this occasion, he delivered a very affecting and patriotic harangue, and afterwards addressed the king in an eloquent speech of thanks. He also laid before the new sovereign an ample memoir on the calamitous state of the kingdom, with a free exposure of the faults which had produced it. The sentiments expressed in this memoir were so much in unison with those entertained by the young monarch, that Malesherbes was appointed minister of state in the month of June, 1775. In this situation, he only sought to extend the sphere of his usefulness. One of the first objects of his care was, to visit the prisons, and restore to liberty the innocent victims of the tyranny of the former reign. He wished to have entirely abolished that arbitrary power of issuing *lettres de cachet*, which had been the instrument of these evils; but being unable to effectuate so great a change, he procured the appointment of a commission, composed of upright and enlightened magistrates, to which every application for such letters should be submitted, and whose unanimous decision should be requisite for their validity. His administration was also distinguished by the powerful encouragement of commerce and agriculture; and in these laudable efforts he was supported by the able and virtuous Turgot, then comptroller-general of the revenue. Turgot, however, was soon after displaced, through the intrigues of the financiers; and Malesherbes did not remain in office long after his friend. Having failed in his liberal and benevolent endeavours to ameliorate the civil condition of the Protestants, by removing the disabilities to which they were subjected, with regard to the solemnization of marriages, and the legitimating of their children, he resigned his situation in the month of May, 1776.

Having a great desire to increase his knowledge by travelling, and being resolved to mix with the different classes of society, he now set out on a journey through France, Switzerland and Holland, under the humble designation of M. Gillaume. He performed his journey in a simple and economical manner, frequently travelling on foot, and lodging in villages, in order to have a nearer survey of the state of the country. He carefully noted down every thing worthy of observation relative to the productions of nature, and the operations of industry; and, after an absence of some years, he returned home with a store of valuable knowledge, which his age and experience fully enabled him to appreciate. Finding his native country at this time much advanced in philosophical principles, he was encouraged to draw up and present to the king two elaborate memoirs; one on the condition of the Protestants, the other on civil liberty and toleration in general, both replete with the enlarged views of an enlightened and patriotic statesman. The difficulties with which the French government was at this period surrounded, rendered it highly desirable that the ministers should have the assistance of a man, whose character was so greatly esteemed by the nation at large; and, in 1786, Malesherbes was again called to the king's councils, but without being appointed to any particular office. He soon found, however, that his views did not accord with those of the other ministers; and, in this critical state of affairs, he made an effort to open the king's eyes, and drew up two spirited memoirs *On the Calamities of France, and the means of repairing them;* but in consequence of the unfortunate ascendency of the queen's party, he was not even permitted to read them, nor could the king be prevailed upon to grant him a private interview. In these circumstances he took his final leave of the court.

Having returned to his country-seat, he published, in 1790, *An Essay on the means of accelerating the progress of rural economy in France*, in which he proposed an establishment to facilitate the national improvement in this important point. When the national convention decreed the trial of the unfortunate Louis XVI. Malesherbes generously came forward, and requested permission to act as one of the counsel of the illustrious culprit. Three had been already appointed; but one of them having declined the office, Louis, who wept at this proof of attachment from his old servant, immediately nominated Malesherbes in his stead. He was the person who announced to the king his cruel sentence, and one of the last who took leave of him previous to his execution. After this event, he again withdrew to his retreat with a deeply wounded heart, and refused to hear any thing more of what was acting on the bloody theatre of Paris. One morning, while walking in his garden, he perceived four men approaching his house, and on going home, he found they had been sent by the convention to arrest his daughter, Madame Lepelletier Rosambo, and her husband, once president of the parliament of Paris. Malesherbes was himself soon afterwards arrested, upon a most absurd charge of "a conspiracy against the liberties of the French people," which was followed, of course, by a sentence of death. His real crime, which his sanguinary prosecutors never pardoned, was his generous defence of the king,—an act in which he gloried. On the day appointed for his execution, Malesherbes left the prison with a serene countenance; and happening to stumble against a stone, he said, (with the pleasantry of Sir Thomas More,) "A Roman would have thought this an unlucky omen, and walked back again." He received the stroke in April 1794, in the 73d year of his age. He was undoubtedly one of the most spotless victims of revolutionary tyranny; and the French government, sensible of the injustice of his sentence, afterwards attempted to make some reparation, by ordering his bust to be placed among those of the great men who have reflected honour upon their country. See *Vie de Lamoignon Malesherbes;* and Aikin's *Gen. Biog.*

MALIC Acid. See Chemistry.

MALINES, or Mechlin, a town of the Netherlands, is situated on the river Dele, by which it is traversed and divided into several islands. The town is large, and contains several good houses and public buildings. The ci-devant cathedral is a large and very beautiful building The town contains six parish churches, and an arsenal, where there is a foundery of cannon. The principal manufactures are those of bed-quilts, thread, and particularly lace, which is universally celebrated. It has some trade in red wheat, which is shipped in lighters to Antwerp. Malines was desolated by a dreadful accident on the 7th August, 1546. During a thunder storm, a powder magazine, containing 2000 quintals of powder, was struck with lightning, in consequence of which many of the buildings were destroyed, about 200 persons killed, and 600 considerably injured. Population 16,600.

MALLET, David, a British poet and miscellaneous writer, was born in Scotland about the beginning of the 18th century. According to Dr. Johnson's account, his family were originally Macgregors, who, upon the dispersion of that clan, took the name of Malloch. Of his early education little is known. By the penury of his parents he was compelled, for some time, to act as *janitor* to the High School at Edinburgh; but he gradually surmounted the disadvantages of his birth and fortune. In the year 1720, he was tutor to the children of a Mr. Home near Edinburgh; and he at the same time attended lectures in the university of that city. In 1723, he accepted the offer of accompanying the two younger sons of the Duke of Montrose to Winchester.

In the year 1723, his first production, the popular ballad of *William and Margaret*, was printed in Aaron Hill's *Plain Dealer;* and in 1728, he published *The Excursion*, a poem in blank verse, in which he evidently imitates the descriptive style of Thompson. About this period he accompanied his pupils in a tour to the continent. His first tragedy, *Eurydice*, was acted at Drury Lane in 1731, and favourably received; but on its revival, some years after, it experienced little success, and has since disappeared from the theatre.

Mallet was now admitted to the company of men distinguished by their rank, or by literary eminence. He lived upon terms of familiarity with Pope, to whom he paid court in a poem entitled *Verbal Criticism*, which was published in 1733. There is in this piece, says Doctor Johnson, more pertness than wit, and more confidence than knowledge. When Frederick, Prince of Wales, was driven from the palace, and set up an opposition court, he endeavoured to increase his popularity by the patronage of literature; and Mallet was appointed his under-secretary, with a salary of two hundred pounds a year. In 1734, he attended the Prince of Orange on a visit to Oxford, and presented to him a copy of verses, written in the name of the University; upon which occasion he obtained the degree of M. A. His tragedy of *Mustapha* was performed at Drury Lane in 1739, under the patronage of the Prince of Wales. It was well received at the time, but has not been revived.

A new edition of the works of Bacon having been prepared for the press in 1740, Mallet was employed to write the life prefixed to it; a task which he performed, upon the whole, with elegance and judgment, but with more knowledge of history than of science. In the same year, he was associated with Thompson in the composition of the patriotic *Masque of Alfred*, which was originally represented at Cliefden, but afterwards altered by Mallet, and brought upon the stage at Drury Lane, in 1751. After an interval of several years, he produced his next work, *Amyntor and Theodora*, a long story in blank verse, written with copiousness and elegance of language, vigour of sentiment, and power of description, but, in many parts, affected and tedious.

Among the persons of rank to whom Mallet obtained an introduction was Lord Bolingbroke, to whom he assiduously paid his court. On the death of Pope, when that nobleman found that he had clandestinely printed an unauthorised pamphlet, called *The Patriot King*, he resolved, in a fit of useless fury, to blast the memory of the poet, and employed Mallet as the executioner of his vengeance. This office he performed with so much severity, that Warburton thought proper to interpose, with an apologetical letter to the editor; to which Mallet replied, in *A Letter to the most Impudent Man Living*. For this service he was rewarded, not long after, with the legacy of Lord Bolingbroke's works, which he published, in 1754, in 5 vols. 4to. but with success far below his expectation. In another instance, however, he appears to have reaped considerable emolument, without any adequate service. Sarah, Duchess of Marlborough, left a legacy of one thousand pounds to Glover and Mallet, on condition of writing the life of her great lord. Glover declined the task, and devolved the whole work upon Mallet, who undertook it, and received the pension to promote his industry; but, when he died, it was found that he had left no vestige of any historical labours behind him.

In 1755, his *Masque of Britannia* was acted at Drury Lane. In 1756, when the unfavourable commencement of the war had rendered the ministry unpopular, he was employed to turn the public vengeance upon Admiral Byng, and wrote a letter of accusation, under the signature of *A Plain Man*, which was circulated with great industry and effect, and for which he was rewarded with a considerable pension. In order farther to promote the ministerial cause, he produced his *Truth in Rhyme*, and his tragedy of *Elvira*, which were both written for political effect. For these services he was, in 1763, appointed keeper of the book of entries for the port of London. After the peace he went to France, where he passed some time; but finding his health decline, he returned to England, and died in April 1765.

Mallet was a man of diminutive stature, but regularly formed. His manners in private life were amiable; and his conversation was elegant and easy. In his character, however, there was nothing elevated or dignified. As a writer, he can scarcely be said to have attained a great degree of eminence in any one species of composition. His poetical works are admitted into our English collections; but, with the exception of his *William and Margaret*, they are now little read. See Johnson's *Lives*, and Aikin's *Gen. Biog.*

MALLICOLLO. See Hebrides New.

MALMESBURY, a town of England, in Wiltshire, is situated upon a hill, nearly surrounded by two streams, which unite to form the Lower Avon, which is crossed by six bridges. The principal streets, which are built on the sides of the roads which pass through the town, are, in general, narrow and irregular, and the houses are old, though there are some very neat ones in the modern style. The church, which formed part of the ancient and venerable abbey, is much admired. The southern porch is a very interesting piece of architecture. The remains of the abbot's house stand to the north-east of the church. The White Lion Inn, the alms-house, and the work-house, with other buildings, present the remains of ancient buildings. There is a beautiful octangular cross in the market-place; and four meeting-houses for the dissenters. The manufactures of Malmesbury consist of fine woollen cloth, gloves, parchment, glue, &c.

The population of the burgh and parish, in 1811, was 1152, and

Inhabited houses, 237.

See Britton's *Architectural Antiquities of Great Britain*, and Moffat's *History, &c. of Malmesbury*.

MALPIGHI. See Botany.

MALPLAQUET, Battle of. See Britain.

MALT. See Brewing.

MALTA, anciently Ogygia and Melita, is an island in the Mediterranean, about 50 miles from the coast of Sicily. It is about 20 miles long, 12 at its greatest breadth, and 60 in circuit. The island consists of an immense oval rock of soft white freestone, covered with a stratum of earth about 8 or 10 inches deep, which was brought from Sicily, and which is taken off every ten years, for the purpose of removing a crust which forms upon the rock, and prevents the penetration of the moisture. The island is well planted, and is divided into small enclosures of freestone. Its productions are, cassia seed, anise seed, cotton, melons, oranges, lemons, and figs; but it does not yield either grain or wine sufficient for the consumption of its population. The coast of Malta is in general steep and rugged, and without any good harbours or safe roads for ships, excepting on the east and west sides of the island, which contain the harbours of Marza and Marza Murzet, separated by an oblong peninsula containing the fort of St. Elmo, which defends the entrance into both.

In summer, the temperature of Malta generally varies from 88° to 95° of Fahrenheit, and in winter it is seldom below 14°. The north and north-west winds are generally accompanied with cold, and the south wind with heat. There are no rivers in the island; but excellent springs of fresh water are frequently found, and, where these do not occur, wells are dug in the rocks. The houses are generally supplied by rain water preserved in cisterns.

The principal trade of the inhabitants consists in cotton, of which they export considerable quantities. They import corn from Italy, cloth, wood, oil, wine, and brandy. Sea salt, and fine flavoured honey, are made in the island; and there is a profitable coral fishery, beside other fisheries. They manufacture gloves and stockings, which are in high repute.

The principal towns in the island are, La Valetta, Civita Vecchia, Citta Vittoriosa, Senglea, Barmola, Citta Nuovo Cottonera, and Malta. La Valetta, the capital of the island, stands on the east coast, and was built, in 1566, on an elevated peninsula already mentioned, having at its extremity the castle of St. Elmo. The town, which is handsome, contains the palace of the Grand Master, the arsenal, the infirmary, the church of the Prior of St. John, and hotels for the knights of different languages. In 1798, it contained 23,680 inhabitants. Civita Vecchia stands on a hill in the middle of the island, and is strongly fortified. It contains several churches and convents, and 5000 inhabitants. Citta Vittoriosa is a fortified town, built on the narrow point of land that projects into the Marza. It is defended by the castle of St. Angelo, which stands on a lofty rock, and communicates with the town by a bridge. The palace of the inquisition formerly stood here. It has an arsenal, a lodgment for slaves, and a Greek church. Senglea, or the Isle of St.

Michael, is a considerable place situated on a peninsula, and separated from Citta Vittoriosa by the canal of Porto della Galere. Barmola is a small town of 700 houses, situated behind Senglea. Citta Nuovo Cottonera is regularly fortified, and includes the old fort of St. Margherita. Malta, Melita, or Medina, is a small fortified place, and a bishop's see. It stands on an eminence near the the centre of the island, and has a cathedral and several religious houses, with extensive catacombs in its vicinity, which form a labyrinth. These towns are separated only by havens. The houses are all of stone, with flat roofs, and covered with plaster.

The island of Malta is every where well fortified. The Forte di St. Thomasso stands upon a point of land about two miles south-east of the town of Malta; and Forte Rosso stands on a peninsula opposite to the island of Comino. Mortars, the mouths of some of which are six feet wide, are cut out of the solid rocks near the different creeks where an enemy might attempt a landing.

The inhabitants of Malta resemble those of Barbary, and speak nearly the same language, viz. the old Punic or Arabic. The Italian, however, is generally spoken by persons of rank in the capital. The population of the island is about 74.705. The small island of Gozo is situated a little to the north-west of Malta. The sugar cane is here cultivated with success. Its area is 40 square miles, and it has several good harbours and strong forts, with a population of 12.464. Comino, which lies between Malta and Gozo, has an area of three square miles, a fort, and 608 inhabitants. The three islands contain 8 cities, 6 towns, 33 villages, and 87,772 inhabitants. See Boisgelin's *Ancient and Modern Malta*, in 3 vols. 4to. See also our article BRITAIN.

MALTA, KNIGHTS OF. See KNIGHTHOOD.

MALTHA. See CHEMISTRY.

MALUS, ETIENNE LOUIS, a celebrated French mathematician and natural philosopher, was born at Paris on the 23d of July 1775, and was the son of Anne-Louis Malus of Mitry. His early education, which he received in the house of his parents, was principally of a literary nature; and his progress was such, that, even in the latter years of his life, he could repeat by heart long passages of the Iliad. At the age of 17, he wrote a tragedy in five acts, entitled the Death of Cato; but his attention had been so much directed to his scientific studies, that, in consequence of a successful examination, he was admitted into the school of engineers. From his progress in mathematical analysis, he was appointed an officer of military engineers; but having been rejected as a suspected person by the minister Bouchette, he lost all hopes of rising in his profession, and repaired to the army of the north, where he was incorporated in the 15th battalion of Paris, and did the duties of a common soldier in repairing the harbour of Dunkirk. The officer of engineers who presided over this undertaking, did not fail to observe how much the talents of Malus were misapplied, and, upon his recommendation, he was recalled by the government and sent to the polytechnic school, where he was soon after employed, in the absence of M. Monge, in giving a course of analytical mathematics. Malus was now raised to the rank of captain, and was employed as professor of mathematics in the school of Metz.

In the year 1797 he began his military career, and was present with the army of the Sambre and Meuse at the crossing of the Rhine, and at the battles of Ukrath and Alterkirk. Having embarked in the wild and unfortunate expedition to Egypt, he assisted at the battles of Chebrees, that of the Pyramids, and likewise at that of Soebisch. He was appointed a member of the Institute of Cairo; and he had the good fortune to discover a branch of the Nile unknown before that time to travellers, to give a description of it, and to construct a chart of the country. The memoir which contains an account of these labours, was published in the first volume of the *Decade Egyptienne*. After the taking of Jaffa he caught the plague, and was so fortunate as to recover from it; and after sharing in the honours and disasters of the French army, he embarked at Aboukir in the British transport the Castor, and arrived in the roads of Marseilles, in October 1801. About this time Malus married Mademoiselle Koch, daughter of the chancellor of the university of Giessen, to whom he had been engaged since his campaign in Germany in the year 1797; and he soon afterwards made himself known to the Institute of France by his *Traité d'Optique*, a work in which he treated in the most general and rigorous manner all the phenomena of reflexion and refraction that depend upon geometry alone. The attention of this distinguished body having been thus drawn to the subject of double refraction, they proposed, as the subject of the prize for 1808, "to give a mathematical theory, verified by experiment, of the double refraction which light undergoes in traversing different crystallized substances." Malus entered immediately on the study of this interesting subject; and during his experiments on calcareous spar, he was conducted to that beautiful property of reflected light, in virtue of which it is polarized, or receives the same character as one of the pencils formed by calcareous spar, by reflection at a particular angle from transparent bodies. Malus lived in the Rue des Enfers; and upon turning a doubly refracting prism to the windows of the palace of the Luxembourg, which were then illuminated by the setting sun, he was surprised to observe, that one of the images of the windows vanished alternately during the rotation of the prism, and he at first attributed this phenomenon to some change which the light experienced in its oblique transit through the atmosphere. Upon farther investigation, however, he found that it was produced by reflexion, and that the windows of the Luxembourg had received the solar rays nearly at the polarizing angle.

In the year 1810, the Institute adjudged the prize of double refraction to M. Malus, who published his memoir under the title of *Theorie de la double Refraction de la Lumiere dans les substances Crystallises*, Paris, 1810, a work which will long be valued as laying the foundation of a new science.

Malus was now elected a member of the Institute, in place of M. Montgolfier. It 1804, he had been made a member of the Legion of Honour, and sub-director of the fortifications of Antwerp; in 1809, sub-director of barracks in the department of the Seine, and in 1810, member of the committee of fortifications, and lieutenant colonel of engineers. After having fulfilled for some time the duties of examiner of the Polytechnic School, he was appointed, in 1811, commander and director of studies in that Institution.

In the year 1811, the Royal Society of London adjudged the Rumford Medals to M. Malus for his researches on light, as inserted in the Memoirs of the Society of Arcueil. Malus, however, did not live long to enjoy these well-merited honours. His health had been injured by the fatigues and diseases which he underwent in Egypt, and their effects were now beginning to become more alarming. Even in the midst of his sufferings, his favourite studies were not neglected. He added many new discoveries to the great fact, with which his name will be for ever associated; and had his life been spared, he would have extended still farther the boundaries of that science of which he had laid the foundation. He expired on the 24th of February, 1812; and Madame Malus, exhausted with the fatigues which were rendered necessary by her ardent affection for her husband, died on the 18th of August, 1813. In the articles Optics and Polarisation, we shall have occasion to give a full account of the discoveries of this eminent individual. For the facts contained in the preceding sketch, we have been indebted principally to the eloge of Malus, written by the celebrated Delambre.

MAMELUKES. See Egypt.

MAMMALIA. See Anatomy Comparative, and Mazology.

MAMMOTH. See Petrifactions.

MAN. See Mazology.

MAN, Isle of, the *Monæda* of Ptolemy, is an island situated in the Irish Sea, at the distance of thirty nautical miles from St. Bee's-head in Cumberland, and 27 from Strangford in Ireland. It is about 30 miles long from east to west, about 10 miles at its greatest width, and between 70 and 80 in circumference. A lofty ridge of mountains runs nearly through its whole length, and covers a considerable portion of the centre of the island. This group, according to Dr. Berger, consists of three chains, separated from each other by high table lands, and it is crossed from east to west by three very narrow openings. The most northern of these lies between the towns of Douglas and Peel, and the most southern forms the narrow channel between the Island and the Calf of Man. The first of these is the highest, and the last the lowest, being under the level of the sea. Snowfield, the highest mountain in the island, is 2000 feet above the level of the sea. The two Barrules, which form the northern and southern extremities of the island, have nearly the same height. Dr. Berger has determined the elevation of no fewer than 89 mountains, and has been enabled to form very interesting sections of the island in various directions.

In the southern parts of this island, the soil is principally loam, but stiff clay likewise abounds. The northern parts consist chiefly of a sandy loam, with a bottom of clay or marl. The immense tract called the *Curraugh*, which extends nearly across the island from Ballaugh to Ramsey, was once a bog, but now produces excellent crops. In some parts of this tract, there is a remarkable layer of peat, which stretches itself for several miles under a stratum of gravel, clay, or earth. The peat is from two to three feet thick, and the gravel from two to four. Trunks of immense oaks and firs occur in the peat, and they all lie in one direction, as if they had been deposited by a torrent. The climate is generally considered to be more mild than that of England or Ireland at the same latitude.

The agriculture of this island, though it has made rapid advances, is still in an imperfect state. Nearly one-third of the whole surface is uncultivated, and appropriated to the feeding either of sheep or cattle. The value of good land varies from 10s. to 40s. per acre. Barley is the principal grain raised by the farmers, as the wheat is subject to smut. Potatoes and turnips are cultivated in great quantities. The cultivation and manufacture of flax is general, and hemp is sown in gardens or in rich enclosures. The native sheep are small and hardy. A peculiar species, called the Laughton, with fine wool, is bred, and many hundreds of cattle are annually fattened for exportation. Nearly one thousand crocks of butter, (weighing 30lbs. each,) are annually sent to England.

This island carries on a considerable commerce, and possesses some manufactures of note. Coarse hats, cotton goods, and linen cloth, are manufactured in different parts of the island. The linen cloth is well made, and is sent to England, to the annual amount of 5000*l*. Great quantities of lead, cattle, sheep, pork, butter, and eggs, are also shipped for England. The principal source of opulence, however, in this island, is the herring fishery, in which above 500 boats are regularly employed between the middle of July and the middle of September. A salmon fishery is also established here, but has now greatly declined. Previous to the last war, it exported to Italy from 2000 to 3000 barrels annually, of the average weight of 150 lbs.

The imports are, manufactured goods of every kind, coal, wine, brandy, and other spiritous liquors.

According to Dr. Berger, very little granite has been observed in this island. It occurs, however, in two or three spots, but it probably forms only beds in the clay slate, which constitutes the central and highest parts of the island. The sea-coast, both on the east and west side of the island, is grey wacke, which covers and almost surrounds the lower part of the clay slate. No animal remains have been found in the grey wacke, which contains beds of grey wacke slate, and flinty slate. The south-east coast, with the exception of a peninsula of old red sandstone which occurs also at Peel, consists of a floetz limestone, containing madreporites and some univalve shells. The Calf of Man is a rocky island, flanked by gloomy caverns and stupendous precipices, is about one hundred yards from the island. It is 206 feet high, and consists of grey wacke. Veins containing galæna occur in the grey wacke, in three different places. They have been wrought more than once, but are now abandoned. Sulphuret of copper likewise occurs.

Several rivers which rise between the North Barrule and Mount Creevy, flow into the sea at Ramsey, Laxey, and Douglas. The largest of these is the Ramsey, which is navigable for vessels of considerable burthen, at the distance of more than two miles from its mouth: The other rivers are inconsiderable.

The principal towns in the Isle of Man are, Castletown, Douglas, Peel, and Ramsey. Castletown is the capital, and is the residence of the principal officers of government. The houses, which are neat and uniform, are situated on the opposite sides of a small creek, and the streets are spacious and regular. In the centre of the town, on a rock, stands Castle Rushen, a magnificent structure of free-stone, and the chief fortress in the island. It was the ancient residence of the sovereigns of Man. This town has also a neat chapel and a freehold.

Douglas is situated near the south part of a bay of the same name. The streets are extremely irregular; but the houses, which skirt the river, have an air of superior beauty. The residence of the duke of Athol is a spacious and stately edifice; and the chapel of St. George, on an eminence west of the town, is an elegant and modern building. There is a free school and a small chapel in the town. A very handsome new pier and lighthouse have been recently erected by government at an expense of 20,000. The bay of Douglas is in the form of a crescent; and at high water it has a depth sufficient for vessels of 500 tons. Ramsey is a neat town, with about 200 houses, built on the shore of an extensive bay. The harbour is protected by a fort mounted with cannon. Several boats, with accommodation for passengers, sail weekly from that port to Liverpool and Whitehaven. Peel, anciently called Holm, is a small but pleasant town on the west side of the island. It has 280 houses, and about 1400 inhabitants; and a free grammar school, a mathematical school, and a free school, have been established in it. Peel castle, situated in Peel island, is a fine remnant of ancient architecture. About three miles from Peel is the Tynwald Mount, consisting of a large mound of earth, ascended by a flight of steps. The principal villages are, Laxey, Bala-sala, and Kirkmichael.

Besides the antiquities already mentioned, there is in the isle of St. Michael, the ruins of a circular fort, erected by one of the earls of Derry for the defence of the harbour. The remains of Rushen Abbey stand between Castletown and Douglas. It was built in 1098; and not far from Douglas are the remains of another monastery. The monument called the *Cloven Stone*, near Laxey, is a circular range of stones on an elevated site. The entrenchment at Ballachury is in great preservation. Many burrows containing urns have been found in the island.

The Manx language, which is a dialect of the Gaelic, still prevails in the interior of the island, but English is commonly spoken in the towns upon the coast.

The royal dignity of the isle of Man was resigned to government by the duke of Athol, in the year 1765, for the sum of 70,000*l.*; but a few years ago an annuity, by way of an additional compensation, was granted to the present duke and duchess. The island is under the ecclesiastical jurisdiction of a bishop, with the title of bishop of Sodar and Man. The population of the island, in 1792, was stated to be 27,913. Dr. Berger calls it 28 000; but Curwen thinks that it does not exceed 23,000. See Townley's *Journal kept in the Isle of Man*, 2 vols. 8vo. 1771; Feltham's *Tour through the Isle of Man*, in 1797 and 1798, 8vo. 1798; and Wood's *Account of the past and present State of the Isle of Man*, 8vo. 1811.

MANCHA, La, is a province of Spain, bounded by New Castile on the south; by Estremadura on the west; by Cordova and Jaen on the south; and by Murcia and Valencia on the east. It is about 43 leagues long and 33 broad, and is divided into the upper and lower province. It abounds in plains of considerable extent, that are waste and almost destitute of trees, and the soil is generally dry and dusty. The province contains 111 parishes, 78 monasteries and convents, 2 cities, 25 towns, and 46 villages. The chief towns are Cuidad Real, the capital of the upper province; Occana, the capital of the lower province; Alcasar and Almagro. Cuidad Real is a regular town, and has good streets, with a square 150 paces long, and 75 broad. The hospital, erected by the Cardinal Lorenzana, cost about 12,500*l.*; and this excellent archbishop established a manufactory of flannels and woollen cloths. Occana contains three parishes, ten convents, and about 2000 inhabitants. The principal productions of La Mancha are, oats, with which the neighbouring provinces are supplied, saffron, honey, and spar. Almagro is famous for melons and potatoes. Immense herds, particularly of mules, are fed in the plains, between Cuidad Real and Santa Cruz de Mudela. The province contains mines of iron, ochre, rock crystal, bole, calamine, antimony, cinnabar, and other minerals. This province formerly possessed many manufactures, but they have now greatly declined. A fabric of lace which employs about 28 000 persons, was set on foot at Almagro. Hard soap is made at Occana; flannels at the same place, and at Campo de Criptance; gunpowder at Alcazar de St. Juan; and there are three refining houses of Saltpetre at Pedronera, Zemblaque, and Alcazar de St. Juan, the last of which yields every year to the crown, for whom it is wrought, 200,000 quintals of sulphur. About from 12,000 to 15,000 people are employed in the spinning of wool. La Mancha furnishes the neighbouring provinces with oats and wine, blond lace, and shoe leather, to a small extent; and it imports shot, spices, salted provisions, hardware, linen, muslins, broad cloth, fine woollen stuffs, silks, and all articles of luxury.

The population of the province is about 206,180. See Laborde's *View of Spain*, vol. iii. p. 325.

MANCHE, La, or the Channel, is one of the departments of France, formed out of that part of Normandy which contained the dioceses of Coutances and Avranches. It is bounded on the north and west by the sea; on the south by the departments of the Ille and Vilaine, and that of Mayenne; and on the east by the department of the Orne and that of Calvados. The soil, which is better adapted for pasture than for cultivation, is partly sandy and partly marshy, and produces corn, hemp, flax, fruits, and roots of various kinds. It has also mines of iron, copper, and cinnabar. The principal manufactures are those of drabs, serges, and glass. In the arrondissement of Coutances the famous Norman horses are bred; and in the neighbourhood of Valogne are the remains of a Roman amphitheatre. The forests occupy about 48,000 acres. The principal towns are,

	Population.
St. Leo, the capital	6987
Valogne	6770
Mortain	2650
Avranches	5413
Coutances	8507

The contributions in the year 1803 were 5,314,741 francs, and the population 528,912.

MANCHESTER, a town of England, in the hundred of Salford, and county of Lancaster, is situated upon the banks of the rivers Irk, Medlock, and Irwell. The population, including the suburbs, was, in May 1818, estimated at 111,000. It has been computed, that about one-fifth of the town is built on the north-west side of the Irwell. This portion is called Salford.

There is nothing particularly remarkable in the early history of Manchester. The place where it stands is supposed by Mr. Whitaker to have been a British station about 500 years before the Christian era. There was, however, no appearance of a town until the invasion of the Romans, when the natives were obliged to collect themselves together for mutual defence. The first name which the Britons gave to the place was, Mancenion, or "a place of tents;" but after its conquest by Agricola, it was called Mancunium. It subsequently received the names of Manduesuedum and Mamcaster, and, in the first or second century, that of Manchester

When the Romans invaded Britain, a castle was built upon the ground, since called Castle Field, near the confluence of the rivers Medlock and Irwell. The protection which a castle afforded, was an inducement, in those times, to build habitations in its immediate neighbourhood. This appears to have been the origin of Manchester. Nothing remains of the castle excepting the foundation. It forms an enclosure of about twelve acres, in which many antique curiosities have, at different times, been discovered. The old town seems to have stood upon the ground now used as a potatoe-market, and upon the land in front of it. Several individuals now living, can recollect the land which was occupied by the ancient town of Mancunium, when "it was a spot which, in appearance, had never served for any other than agricultural purposes."

The Romans formed a summer camp upon the elevated ground near the junction of the Irk and Irwell. Along a street, now called Hanging Ditch, they conducted from the river Irk a fosse, over which they constructed a draw-bridge. Some traces of the old ditch may still be discovered; and the bridge, though filled up, and built upon for ages, has one of its arches remaining. Towards the close of the ninth century, Manchester was nearly destroyed by the Danes; but it was afterwards rebuilt by Edward the Elder, king of Mercia, who converted it into a strong fortification.

Manchester was the residence of one of the Saxon chieftains, or lords, who was a member of the parliament, and possessed of great authority. The principal personages of his suite lived also in much state; and their residences were, no doubt, the halls and districts of Aldport, Beswick, Ancoats, and Collyhurst. About this time, the ancient churches of St. Mary and St. Michael were built. The lord lived on the eminence of Hunt's Bank, at that time called Baron's Court. On the road from this place to these churches a few houses were erected, which were probably the origin of the streets now called Deans' Gate and St. Mary's Gate. The next houses which were built, after these, were probably contiguous to the field appropriated for a market place. Houses were gradually built on every side, and the intervals in time filled up. The earliest townships in the precincts of Manchester were, Salford, Chetham, Newton, Ardwick, and Charlton-row.

A charter was granted to Manchester in 1301, constituting it a free borough, by Thomas Grelle, lord of the manor. Twelve years afterwards the lord of the manor was John de la Warr, the last male heir of whose family, lord de la Warr, who was in orders, procured a licence in 1422 for erecting the collegiate church of Manchester, and endowed it liberally. On this and other pious foundations, he is said to have bestowed the value of twelve lordships. The first collegiate church, like the churches of St. Michael and St. Mary, was built of wood, and in course of time fell into decay. In consequence of the building of a new church, Hanging Ditch, which had been for some hundred years the bed of a river, was drained, in order, probably, to serve for the foundation of the houses which gave rise to Fennel street, and part of Long Millgate.

The grammar-school, situate in the latter place, was founded by Hugh Oldham, Bishop of Exeter, in the beginning of the 16th century.

Manchester was one of the eight places upon which Henry VIII. in the year 1540, confirmed the privilege of Sanctuary. In the following year, however, the privilege was transferred to Chester.

Writers are not agreed with respect to the period when Manchester first became distinguished for its manufactures. A reference to the acts of Parliament in the reign of Edward IV. will shew, however, that at that time it was noted for the production of a sort of woollen goods, called Manchester cottons, rugs, friezes, and other articles.

In the year 1578, Manchester is stated to have had 10,000 parishioners. About this time a new foundation was given to the college, and it was incorporated by the denomination of Christ's College in Manchester. In the same year Lord de la Warr disposed of the manor, in consequence, probably, of a dispute which occurred between him and the town respecting the appointment of a boroughreeve. It was purchased for 3000*l.* by Sir John Lacye of London. In 1596 it was resold to Sir Nicholas Mosley for the sum of 3500*l.* and still continues in the possession of his family.

In the reign of James I. Manchester was visited by a pestilence, which carried off nearly 1000 persons. About this time Salford had risen to some importance; and Trinity Chapel was founded for the convenience of its increasing population.

In the dispute between Charles I. and the Parliament, Manchester warmly espoused the part of the latter. It was in consequence, in 1642, besieged by a strong force under the Earl of Derby, who, after a fruitless effort of several days, in which he lost a considerable number of men, was obliged to retire. Three years afterwards Manchester was again visited with a dreadful pestilence.

About this period this town had the reputation of being one of the most industrious in the north of England. Its principal articles of manufacture were woollen friezes, fustians, mingled stuffs, tapes, &c. In 1651 Chetham Hospital and Library were founded. St. Ann's church was erected in 1708, and within fifty years of this time, an act was granted for a new church, which was dedicated to St. Mary, the old one of that name having been destroyed by time. In 1758 the trade of Manchester had greatly improved; and from this period we may date its commercial superiority. No town in the kingdom has, during the present reign, had a greater proportional increase in trade and population than Manchester.

Manchester is particularly distinguished for its spinning manufactories, the progress of which, in this town, has, during the last sixty years, been extremely rapid. The first improvement of any material importance in the operation of weaving, was made in the year 1750 by Mr. John Kay of Bury. To this gentleman we are indebted for the introduction of the fly-shuttle. Previously to this period the manufactures were consumed in our own country, but fluctuations in the prices of different articles occurring, and a demand being made for them abroad, a foreign trade commenced. The quantity of goods consumed in consequence greatly increased, and the system of manufacture then adopted was found inadequate to supply what was required. The number of persons employed was of course augmented, and the energies of genius, and the efforts of industry, were called into action, in the improvement of the imperfect machinery which the country then possessed. Carding and spinning were at first performed by the hand, until, in the progress of time, the rude application of ruder machinery facilitated these operations, and rendered the labour of individuals more productive. One improvement succeeded another, until the whole began to assume a systematic aspect. Hence the origin of factories, and the division of the trade into its various departments. The carding machine, invented about sixty years since, underwent considerable improvement, and was in great requisition. At first one boy or girl was able to work two pairs of stocks; but, by the application of this machine, one person could work four or five pairs. In the lapse of about ten years, Mr. Hargreaves of Blackburn invented the spinning jenny. This machine was an important addition to manufactures, enabling one young person to work ten or twenty spindles at a time. It was soon found that, by modifying the construction of the machinery, a single person might work 20 pairs of hand-cards, or 40 spindles. A farther abridgement of labour was effected, by the introduction of rotatory motion into the machinery; the power of horses was, in a short time, had recourse to, and this again was soon superseded by that of water.

Nothing perhaps tended, in a greater degree, to elevate Manchester as a manufacturing town, than the enterprising spirit and valuable inventions of Mr. (afterwards Sir Richard) Arkwright. This distinguished individual introduced new principles into both carding and spinning. By means of his machinery, the fibres of cotton were laid parallel to one another, and the thread rendered more uniform than it could be by the methods previously employed.

Though, in most parts of the country, waterfalls were used for the purpose of working the machinery, yet, in some few instances, steam engines were employed; but being constructed on the defective principles of Newcomen and Savary, and the expense of fuel being great, their adoption was attended with insuperable disadvantages.

The machine denominated the *Mule* was invented by Mr. Samuel Crompton in the year 1780. In consequence of the many advantages attending this valuable machine, an extension of trade was again occasioned. It did not, however, appear in its present perfection until the application of the new steam engine on the principles of Mr. Watt. For this improvement we are indebted to Mr. Kelly of Lanark: he was the first person who worked *mules* by machinery. Prior to the introduction of the improved steam engine, manufactories were confined to those places which furnished a considerable stream of water to turn the machinery: but, subsequently, "instead of carrying the people to the power, it was found preferable to place the power amongst the people, wherever it was most wanted."

The scutching, or blowing machine, invented by Mr. Snodgrass, and improved by Mr. Arkwright and Messrs. Strutts, made its appearance in Manchester about the year 1809. It is very useful for cleaning cotton; and it is rendered still more valuable, by superceding almost entirely the employment of females in one of the most degrading parts of the trade. The power-looms, (or looms worked by machinery) were about this time much in use. The machine, invented in 1803 by Mr. Thomas Johnson of Bradbury, for warping and dressing warps preparatory to weaving, is deserving of particular notice, not only on account of its performing the work better and cheaper than the former method, but also because it greatly facilitated the operation of the power-looms. Various other machines have been introduced into the trade, which it is not necessary for us to particularize; but it may be proper to mention, that, by the aid of the machinery now in use for spinning, "one person can produce more yarn in a given time, than 200 could have produced 50 years ago."

These facts relative to the progress of the spinning trade in this town, have been borrowed from a highly interesting essay by John Kennedy, Esq. inserted in the third volume (second series) of the *Memoirs of the Literary and Philosophical Society of Manchester.* From the same essay we make the following extract, referring our readers to the essay itself for more information on the subject.

" In the year 1817, from authentic documents, and the best estimates I could draw from them, the quantity of raw cotton consumed, or converted into yarn, in Great Britain and Ireland, was	110,000,000 lbs.
Loss in spinning estimated 1½ oz. per lb.	10,312,500 lbs.
Quantity of yarn produced	99,687,500 lbs.
Number of hanks* (supposing the average to be 40 per lb.)	3,987,500,000
Number of spindles employed, (each spindle being supposed to produce two hanks per day, and 300 working days in the year)	6,645,833
Number of persons employed in spinning, (supposing each to produce 120 hanks per day)	110,763
Number of horses' power employed, (supposing 4½ oz. of coal to produce one hank of No. 40, and 180 lbs. of coal per day, equal to one horse's power)	20,768

The spinning trade is becoming every year more extensive. During the summer of 1818, several new factories were built in the immediate neighbourhood of Manchester. They are composed almost entirely of brick and iron, and are therefore secure from accidents by fire. Considerable quantities of yarn are annually exported. That which remains in the country furnishes employment for a variety of trades, and an immense number of individuals.

" The wire card manufactory of this town is another remarkable instance of the successful substitution of machinery for manual labour. The accuracy and rapidity with which this machinery performs its work is very striking and beautiful; and although the mode in which it operates cannot be made intelligible by a verbal description, yet the following may be taken as pretty nearly the order of their operations, viz. The leather being placed in a stretching frame attached to the machine, and the wire placed on a reel, with the end presented to the machine, (1) the feeders bring forward a piece of wire of the required length to form the staple, whilst (2) the piercers pierce the holes in the leather; (3) the crowner holds the protruded piece of wire fast; (4) the shears cut it off; (5) the staplers bend it into the form of a staple; (6) the sliders carry it forward to the leather, and guide it through the holes already pierced for its reception; (7) the crookers give it the knee bend; (8 the sliders deliver, and the crowner strikes home the staple; (9) the leather is moved the required distance for placing another staple, when the repetition of the same operations again takes place in alternate succession, at the rate of about 150 staples per minute. Upwards of sixty of these machines are tended and kept in order by eight persons, viz. 3 men, 4 boys, and 1 girl; and the average quantity of work done by them may be estimated as follows: Say with 60 of the machines, taking the medium fineness of cards at 250 staples, or 500 single teeth per square inch of leather, each machine will set 1 foot 6 inches square, or 90,000 staples per day, making for the whole 90 feet square of leather, which, of the average size, is about 10 hides per day, and the total number of 5,400.000 staples per day. The weight of this wire is about 130 lbs. and taking each staple at the average length of $\frac{94}{100}$ of an inch, the whole length of wire used will be within a fraction of 80 miles per day." The preceding observations, respecting the manufacture of wire cards in Manchester, are an abstract of a description which was politely drawn up, for the use of the writer of this article, by J. C. Dyer, Esq. the present proprietor. This gentleman is a native of America, whence he brought the invention into this country. Since its introduction here, however, he had improved it very materially. For ingenuity and beauty it is perhaps scarcely equalled, and certainly not surpassed, by any other machinery in the kingdom. It is worked by the steam engine. Some further particulars respecting this machinery, accompanied with an engraving, may be seen in the article CARDS.

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* A hank of cotton yarn is 840 yards in length.

There are other manufactories of considerable magnitude in the various branches of trade. The printing, dyeing, and bleaching concerns in and near Manchester, are very extensive. We may also mention several well conducted sulphuric acid or oil of vitriol works, and a number of very large iron founderies.

The principal articles of cotton manufacture made in Manchester at present, are velvets, fustians, dimities calicoes, checks, tickings, jeans, shirtings, ginghams, quiltings, handkerchiefs, nankeens, diapers, muslinets, muslins, cambrics, and almost every description of fancy and ornamental cotton, and cotton and silk goods.

Manchester is particularly distinguished for its public charities. "No town in the kingdom has exhibited greater proofs of public spirit, put into motion by the best feelings of the heart, in the creation of institutions for the amelioration of human misery; the erection of suitable buildings for that purpose; in perseverance in annual contributions for the perpetuation of the blessings imparted; or in making necessary provision for the prevention or the cure of the evils which perpetually attack the lower orders of society." The first we shall notice is Chetham's hospital, commonly called the College. It has already been referred to in the historical sketch of Manchester. In this institution 80 boys are maintained and educated, from the age of 6 to 14; and, at the expiration of that term, furnished with a suit of new clothes, and put apprentices, with a small premium, to some useful trade. In this institution there is a valuable public library. It contains between 18,000 and 20,000 volumes, in a variety of languages, besides a number of scarce manuscripts, and some rare natural curiosities.

Opposite Piccadilly is the handsome set of buildings called the Infirmary, consisting of a large general hospital, a dispensary, and a lunatic hospital and asylum. It is inclosed at the back with a wall, and to the front with neat iron palisadoes, within which are a large pond, the public baths, and some fine walks. The institution was founded in 1752, and originated in the philanthropic exertions of the late Joseph Bancroft, Esq. ——— Massey, Esq. and the late Charles White, Esq. It was erected by voluntary subscription.

The Lying-in Hospital was instituted in 1790. Six years after, it was removed to the eligible building which it now occupies in Stanley Street, Salford. A more suitable situation for the purpose could not easily have been found. It is built upon the bank of the Irwell. The building is commodious, and possessed of every convenience which could be desired. We must also mention the Ladies' Auxiliary Society. Poor women are accommodated by this institution with the loan of various articles which they may require during their confinement, and, in some cases, presented with clothing for the infant.

In 1796, the House of Recovery, or Fever Ward, was instituted. It is situated in Aytoun Street, a short distance from the Infirmary. It contains 21 wards, and has accommodation for 100 patients. The house is well ventilated, and every precaution taken to prevent the spread of infectious fever.

An association was formed in the year 1791, at the suggestion of the Rev. Dr. Clarke, denominated the Strangers' Friend Society.

In King Street there is an institution for the benefit of poor persons afflicted with diseases of the eye; and measures have lately been taken, which have insured the immediate establishment of a Lock Hospital and Penitentiary.

Charity schools are numerous in Manchester. In the Sunday schools belonging to the established church, as well as those of the dissenters, many thousand poor children are educated. The Royal Lancasterian School was founded on the 25th October, 1809, and, on that account, is very generally called the Jubilee School. It gives instruction to 1000 children. It is situated in Marshal Street, Great Newton Street. There is a smaller establishment on the same system in Lever Street. The two national schools, upon the principles of Dr. Bell, were founded on the 26th June, 1812. One is situated in Granby-row; the other in Bolton Street, Salford. They are calculated to afford accommodation for 300 boys, and an equal number of girls. The Ladies' Jubilee School is situated in Strangeways. It is formed exclusively for female children intended for domestic service. This institution was founded in 1809. The Boroughreeve's charity consists of money and lands bequeathed by different charitable individuals, for distribution among "the poor, aged, needy, and impotent inhabitants of Manchester." It receives its name from the disposal of the money being left at the discretion of the Boroughreeve for the time being. A great number of sums of money have been bequeathed, at different times, for benevolent purposes, which our limits prevent us from mentioning. The Manchester Poor House was erected in 1792. It is a handsome edifice, possessing every convenience. It is situated in Strangeways, adjacent to the Ladies' Jubilee School. There is a similar institution in Greengate, Salford. Besides the charities above enumerated, Manchester possesses several others, for an account of which we must refer to the "*Picture of Manchester.*"

Manchester has many handsome buildings for amusement and convenience. It has two theatres; the largest, situate in Fountain Street, is very spacious and elegant. In the same neighbourhood there is a suitable concert-room. The Exchange is a singularly fine and spacious edifice, built of Runcorn stone, and of the Doric order. It was erected by subscription in 1808, and is situated in Exchange Street, fronting the market-place. The newsroom which it contains is extremely magnificent; the area is 4060 feet. The upper rooms are made of corresponding extent, and used for public dinners, exhibitions, meetings, &c. The newsroom is well supplied with London and provincial newspapers, and a number of periodical publications. The annual number of subscribers amounts to nearly 2000. The merchants and tradesmen of the town resort hither for the transaction of business. The portico is a beautiful building of the Ionic order; it is situated in Mosley Street, and was built by subscription in 1803. It contains a very commodious room, well supplied with newspapers of every description. Above this room is a handsome gallery, appropriated to the purpose of a library. This institution is much frequented by professional gentlemen.

Manchester is deserving of much credit for the encouragement which it gives to the promotion of literature, science, and the arts. In this respect the Literary and Philosophical Society, founded in 1781, is worthy of particular notice. The origin and design of this excellent institution is thus explained in the preface to the first volume of the Memoirs of the Society, published in 1789: "Many years since, a few gentlemen, inhabitants of the town, who were inspired with a taste for literature and philosophy, formed themselves into a kind of literary club, for the purpose of conversing on subjects of that nature. These meetings were continued, with some interruption, for several years; and many respectable persons being desirous of becoming members, the numbers were increased so far, as to induce the founders of the society to think of extending their original design. Presidents, and other officers, were elected; a code of laws formed; and a regular society constituted, and denominated the Literary and Philosophical Society of Manchester." The principal gentlemen who were members of this institution at the time of its origin were, Dr. Percival, Mr. Thomas Henry, Dr. Eason, Charles White, Esq. the Rev. Dr. Barnes, the Rev. Samuel Hall, and upwards of thirty other gentlemen, several of whom were well known for their talents and erudition. Exclusively of these, they elected about an equal number of honorary members, comprehending some of the most illustrious literary characters in Europe and America. The society has continued to publish a volume of its memoirs at different intervals. Some of these volumes are of considerable importance, and all of them are highly interesting. The society, in its present state, ranks very high, not only on account of the number, but the talents of its members. The society at present consists of 86 ordinary members, 32 honorary members, and 43 corresponding members. The names of Dalton, Henry, and others of its members, whom it is unnecessary to specify, are well known in the scientific world.

Courses of lectures upon the different branches of literature, science, and the arts, are frequently delivered by resident and itinerant lecturers.

In 1767, the Manchester Agricultural Society was established. The only publications which emanate from this institution, are the annual reports of the premiums bestowed on deserving individuals, who have contributed to the improvement of agriculture. Small presents are given by this society to farmers' servants, who have distinguished themselves for the length of their servitude, or the propriety of their conduct. It also confers rewards on cottagers, who, by their industry, have maintained their families without parochial assistance.

The Commercial Clerks' Society was established in 1802. The object of it is to provide a fund for the relief of sick and infirm members in distressed circumstances, and the distressed widows and children of deceased members. There are in this town several other institutions of a similar nature; such, for instance, as the Philanthropic and Commercial Travellers' Society.

Manchester contains at present 16 churches of the establishment, and about double the number of chapels for dissenters of various denominations. Several of the churches are remarkably handsome. They are built of various orders of architecture. Our limits restrain us from noticing them all; but a history of the town would be very imperfect, which did not contain some account of the Collegiate church, with the churches of St. Mary and St. Peter. The Collegiate church is built in the rich ornamented Gothic style of architecture. It is decorated on the exterior in the prevailing taste of the 15th century, with grotesque figures projecting from the roof. The interior is made to correspond. The seats in the body of the church, with the exception of two only, are free to any of the parishioners. The length of the cross aisle, from the south porch to the north door, is 100 feet; and the entire breadth of the church, including Brown's chapel, is 120 feet. The length of the outside of the whole building, from east to west, is 216 feet. The church is undergoing very considerable improvements; nearly the whole of the wood-work inside has been made anew, and the exterior walls are gradually taken down and rebuilt in all their pristine elegance and eccentricity. A considerable time will probably elapse before the alterations are completed.

The church of St. Mary is of the Doric order. It has a fine spire steeple, the height of which is 186 feet. It is supported by eight Ionic pillars. The lantern, which has a very striking appearance, is surmounted by a large globe, on the top of which is a cross. The interior of the church is very elegant. It contains several paintings of merit.

St. Peter's church is a singularly elegant piece of architecture. It has two beautiful entrances; they are at opposite ends of the church. It is of the Doric order, and has much the appearance of a Grecian temple. Many of the other churches are great ornaments to the town, and the inspection of them would afford much gratification to the man of taste and the antiquary. The chapels are extremely neat and elegant. Of these there are no fewer than 32.

Manchester is governed by a boroughreeve, two constables, a deputy constable, and a number of inferior officers. It contains several courts of law. A Quarter Sessions for the trial of criminals, and different law-suits, is held at the Court-House in the New Bailey. A stipendiary magistrate is appointed to sit every day, at the same place, for the administration of justice in cases of less importance. An act of Parliament was granted in 1808, for the establishment of a Court of Requests, which is open every fortnight, for the recovery of debts not exceeding five pounds. Besides these, there is a Baronial Court in Manchester, and a Hundred Court at Salford, held for the same purpose.

The New Bailey Prison is a large building in Stanley Street, Salford. The foundation was laid in 1787, and since that time it has served as the only prison for a very extensive district, containing several hundred thousand persons. It has lately been much enlarged. Until within two or three years, the outside walls, which were in a square form, were each of them 120 yards in length. The prison is now nearly twice as large. It has now two elegant entrances of handsome rusticated stone. It presents altogether a very firm and secure appearance. It contains a commodious court-house, with a grand jury room, and apartments for the accommodation of magistrates, counsel, &c.

Manchester has lately received many improvements. The streets are well paved, and nearly all the foot-paths flagged, for the accommodation of foot-passengers. The entrances into the town, in almost every direction, present an elegant appearance. In the winter time the streets are lighted with 2758 lamps, many of which are lighted with gas. The use of gas-lights was first shewn in Manchester, in the extensive factory of Messrs. Phillips and Lee, which has been lighted with them since the year 1805. They have since been introduced into other factories. In 1817, a large gas apparatus was erected on a piece of ground between the lower end of Bridge Street and St. Mary's church, from which the pipes, which are laid in all the principal streets, are supplied. By this means private houses and shops are furnished with gas; and the latter, in particular, look extremely brilliant.

The town is plentifully supplied with water from a magnificent reservoir about two miles from the market-place. The water is conveyed in stone pipes through all the principal streets. The height of the reservoir is so considerable, compared with the level of the town, that in the event of accidents by fire, a leather pipe can be attached to the stone pipes, in different places, so as to serve as a water-engine for extinguishing the fire.*

Considering the extent of the population, Manchester is remarkably peaceable and quiet during the night-time. Fifty-three watchmen parade the streets continually from night till morning. Manchester supports a great number of stand-coaches. It has also stage-coaches, proceeding at different times of the day to all parts of the kingdom.

In some parts of the town the houses are large and handsome. Portland Place and Mosley Street, in particular, have a very fine appearance. The gentlemen's seats in the neighbourhood are numerous, and many of them remarkably neat and elegant. The increase of buildings in the town and vicinity has, during the last summer, been probably much greater than was ever known before in the same space of time.

The principal rivers near Manchester are the Mersey, the Irwell, the Irk, and the Tib, by which the suburbs of the town, in different places, are intersected. Over these rivers several handsome bridges have been erected. Some of them, especially those most recently constructed, are very great ornaments to the town, and are highly creditable to the taste and skill of the architects.

Manchester possesses many advantageous means of communication with other towns. The inland navigation, by means of the various canals, is particularly worthy of notice. By these there is a direct conveyance for passengers and goods of every description, to and from Liverpool, Rochdale, Hull, and other places. The canal belonging to the Duke of Bridgewater is doubtless the finest in the kingdom.

The climate of Manchester is healthy, though rather moist. The average quantity of rain during the year, according to the observations of Mr. Dalton, is about 34 inches.

In drawing up this article, we have been much indebted to Mr. Aston's *Picture of Manchester*, and the well-known historical works of Whitaker and Aikin.

MANDARINS. See China.

MANDING is a country of Africa, situated on both sides of the river Joliba. See Africa.

MANEGE, or Manage, is a term which is used to denote the art of breaking and riding horses, according to the most approved rules; or the place set apart for the performance of equestrian exercises. We have borrowed the word from the French, and they from the Italian *maneggio*. Some derive it from the Latin, *a manu agendo*.

The ancients do not seem to have paid much attention to the art of horsemanship, which appears to have been first cultivated, in modern times, by the Italians; and we find that, some centuries ago, men of all nations were in the habit of repairing to Naples and Rome, in order to be instructed in the method of dressing horses for war or the manege. The first who wrote upon the subject was one Frederick Grison, a Neapolitan, whose reputation as a horseman was so great, that our Henry VIII. sent for two of his pupils to England, who introduced the art among our countrymen. Several other Italians afterwards wrote treatises upon horsemanship, but their rules were taken, for the most part, from the work of Grison. The most famous horseman which Italy ever produced was Signior Pignatelli, also a Neapolitan. He was a very able master, and made many excellent scholars; but never wrote upon the principles of the art. The first French horsemen, La Broue, Pluvinel, and St. Anthoine, were pupils of Pignatelli, and introduced his method into France. La Broue wrote one of the best books upon horsemanship in the French language. Pluvinel was also a good horseman; but his invention of the three pillars, which he gave out as an infallible method, has been reprobated by the best subsequent writers on the subject. M. de Solleysel, of the Royal Academy of Riding in Paris, published a work called *Le Parfait Mareschal*, which is a treatise on farriery rather than on horsemanship. It was translated into English by Sir William Hope of Kirkliston, who added to it a compendious supplemental treatise on horsemanship, compiled from the best previous writers. It is unnecessary to say much of our earliest English writers upon this subject, such as Blundevil, Markham, and De La Gray, who treat more of farriery than of horsemanship. After all these came the prince of horsemen, the great Duke of Newcastle, who was so perfectly master of the art, and wrote of it so copiously and so well, that subsequent authors have done little more than copy or abridge the rules laid down in that excellent work.

The principal matters in which the pupil is to be instructed at the manege are, to sit on horseback with firmness, ease, and gracefulness, and to guide his horse accurately in going straight forward, to the right and left, or sideways, at a walk, trot, or gallop, to halt at once, and to rein back without difficulty or opposition. It must be obvious, however, that in order to perform these exercises with spirit and ease, the horse must go through a regular course of previous instruction as well as the horseman; and to this point, therefore, we shall first direct the attention of our readers.

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* The Reservoir is 600 feet square at the surface, and 22 feet deep; and, making a proper deduction for the slope of the bank, contains, when full, about 212,232 tons of water.

Most horses are by nature extremely docile, and, when proper means are used with them, they shew themselves very well disposed to obey their masters. The latter, therefore, ought to endeavour, from the commencement, to acquire the confidence of the animal, by kind and gentle treatment, and by avoiding all unnecessary severity. Some horses, indeed, are naturally vicious or obstinate, and must be occasionally coerced by punishment; but the chastisement should be inflicted with judgment and discrimination. Spirit has been sometimes mistaken for vice; and many horses not naturally vicious, have been rendered so by severity and injudicious treatment.

A horse may be dressed to the manege at almost any age, provided he has sufficient strength and symmetry; and many prefer for this purpose, a sound, active horse, from five to eight years old, to any other. If a horse, however, is to be trained to the manege from his infancy, his education may commence between the age of 2 and 3 years; and it will greatly facilitate future operations, if he has been previously accustomed to be housed during the winter. About the age above mentioned, a halter or cavesson should be put upon the foal, in order that he may become familiar with it. It is proper, too, that the groom, every time he cleans the animal, should lift each of his feet alternately, and strike the hoof gently with a piece of wood, or a hammer; after which, he will readily submit to be shod when necessary. In the next place, before feeding, the groom should put a saddle on the back of the foal, and remove it again, but with great caution; and continue this practice from time to time, until the animal has become habituated to it. The girth may then be bound over the saddle, but not too tight, and the foal be left to stand and feed. The hand should also be occasionally laid gently on the saddle, in order that the animal may be accustomed to be handled in this manner without feeling any alarm. We cannot too often repeat, that these things, and indeed all lessons, must be taught by degrees, and by the most gentle means; otherwise we run the risk of spoiling the temper of the animal, and of rendering it either timid or vicious. By following the method prescribed above, the foal will gradually become so docile and obedient, that, when fit for riding, he will readily submit to be shod, saddled, and mounted; for having been familiarised to these things by good treatment, he will no longer be apt to betray any alarm or uneasiness.

When the horse is sufficiently advanced to be fit for the manege, he ought to be made to run in the *longe* for some time, either under cover, or in the open air, and without a rider. For this purpose, an easy cavesson is to be put upon his nose, and he is to be made to go forward round you, while you stand quiet holding the longe, and another man, if necessary, may follow him with the *chambriere*, or long whip. This exercise should be performed with great gentleness, and but little at a time, in order that the horse may not be fatigued, stupified, or discouraged. Should he carry his head low, he may be longed with a cord buckled to the top of the head-stall, and passing from thence through the eye of the snaffle into the hand of the person who holds the longe. The first lesson for a horse is to go freely forwards both to the right and to the left. You must never suffer him to go false, nor allow his pace to be shuffling or irregular; but endeavour to bring him to a firm, regular, and determined motion. No bend must be required of him at first; the cord which is used should be long and loose, and the circles large, in order that he may go free and unconstrained. When you mean to change hands, stop and caress him, and entice him gently to come up to you. The trot, we may observe, is the pace which enables all quadrupeds to balance and support themselves with firmness and ease; and it is, therefore, the most proper for giving a determined motion to the horse. When he is perceived to go firmly, freely, and lightly, his head may be tied a little inwards by degrees; more and more, as he grows more supple, both in trotting and galloping.

After the horse has been exercised for some time in the manner above described, and is deemed sufficiently prepared for the rider, he may then be mounted. At this period, a *trench* or snaffle, and cavesson, only should be used, until the horse has been somewhat taught. Some of the elder writers on horsemanship recommend the use of the bit from the beginning; and this practice prevailed much in some of the French schools. But we conceive it to be the better practice to dispense with the bit at first, as it is apt to occasion too much pressure on the bars of a young horse, to make him carry his head low, and impede the free motion of his shoulders. The bit and bridle should not be introduced, until the horse has been taught to carry his head high, and he has become well determined, light in hand, and free in his motions.

The longe may now be attached to the ring of the cavesson. The horse must be accustomed, from the beginning, to stand still to be mounted, and not to move until the rider please; and, for this reason, care should be taken not to alarm him. Of the method of mounting, and the proper position of the rider, we shall have occasion to speak in the sequel. When the horse has been mounted, he should first be taught to be firm and determined in his motions, and to go well into the corners, both with his fore and hinder parts, on a walk, without any bend, and to be very light in hand. The rider, too, must always be prepared to give the proper aids with his hands and legs.

The next thing to be attended to is to give the horse a fine carriage; which must be done by bringing his head into such a position, as to form a perpendicular line from the forehead to the nose. When this has been effected, the rider should next endeavour to bring the horse's head a little more inwards than before, by pulling the inward rein gently and by degrees, and then gaining a little on the shoulders, by still keeping the inward rein the shorter, and crossing the outward rein a little over, and towards the inward one. In order to explain the meaning and effect of these operations, it is necessary to observe, that the whole figure of the horse is determined by the position of the head and neck, because the joints of the neck are intimately connected with those of the back. The shortening of the inward rein, therefore, serves to bring in the head and procure the bend; while the crossing over of the outward rein tends to make the bend perpendicular, and thus not only places the horse in the most beautiful position, but also the better enables him to go through the exercises of the manege. A horse brought into this position, and rode gently, occasionally applying the necessary aids, (to be afterwards explained) learns of himself to use his shoulders and fore legs, and acquires both freedom and firmness in his paces.

Before proceeding farther, it may be proper to describe the different paces of a horse; and to distinguish the natural from the artificial, and the true from the false.

The natural paces of a horse are, the *walk*, the *trot*, and the *gallop*. In walking, the horse moves off with one of his fore feet, which is immediately followed by the hind leg of the opposite side; and so with the other fore and hind leg. The trot differs from the walk, not merely in the greater velocity of the motion, but in this also, that the horse always moves the two opposite legs together. The gallop is a series of leaps; and it is regular when the horse lifts his two feet on one side at the same time, and follows with those on the other side. When the right feet move off first, the horse is said to gallop to the right; when the left move first, he is said to gallop to the left. A horse may not only gallop, but also trot and walk false. In galloping, for example, a horse goes false, when, in going to the right, he leads off with the left leg; or, in going to the left, he leads with the right; or, in case he is disunited, by which is meant, if he leads with the opposite leg behind to that which he leads with before. A horse may thus be disunited to the right or to the left. He may likewise be at the same time both false and disunited. Thus he is both false and disunited to the right, when in going to the right he leads with the left leg before, and the right behind; and he is both false and disunited to the left, when in going to the left he leads with the right leg before, and the left behind; although, in both cases, the hinder leg is with propriety put forward.

The three natural paces which we have described above are converted into cadenced motions (or artificial paces) by art and skill, by shortening or quickening the motion of the horse; and thus are formed the actions of the terre-a-terre and demi-air, or demi-volte, which are a species of short gallop, the horse making a leap forwards, the two fore legs being first, and the two hind legs following; and of what are denominated the high airs, the curvets, groupades, ballotades, and capriols, in which the horse makes a leap upwards.

The amble is by some reckoned among the natural paces; and it seems to be natural to some horses, though not to others. It may, however, be taught, but is not practised in the manege. In ambling, the horse leads off at once with both feet on one side, and changes immediately with the other side. It is an easy motion for the rider, but very fatiguing for the horse.

When the horse has learnt to go forward freely, he should be exercised, for some time, in the manner above pointed out, first at a walk, and afterwards in trotting, care being always taken that he preserves his proper carriage, and goes well into the corners both with his head and croup. The object of the trot is to render the horse supple in the shoulders, and to make him go with a determined, free, and united action. For this purpose, it is not sufficient that he lifts and throws out his legs; he must be taught to do so in a vigorous manner, and to raise and put down his feet with a certain activity, spirit, and elegance. There is no pace so well adapted for giving this determined and spirited action as a trot; in which, therefore, the horse ought to be exercised for a considerable time, until he performs his work with ease, freedom, and vivacity.

If the horse is well formed, but retains his strength, he is light in hand. A horse of this description should be forced forward, and put to the extended trot. When he is found to go freely, he should be brought together by degrees, until he bends his legs, and goes united and equally. If, when kept together, he slackens his pace, and retains himself, give him the aids briskly, and push him forward, still keeping him gently in hand. If the horse is ill formed, or cross made, and goes disunited, without retaining himself, he is heavy in hand. In this case you must throw him back upon his haunches, and shorten his steps, in order that he may collect his strength, and go united and firm. You must not suffer the horse to sink his neck and poke out his nose. When this happens, hold the reins tight, in order that when he attempts to alter his position, the bit or mouth-piece may punish his bars, and thus force him to hold himself erect. To work up a horse's head and neck into the proper position, is not easy; it requires a certain delicacy of hand, which never fails of success, but which it is impossible to describe with any degree of precision, as it depends entirely on that nice feeling in the horseman, which can only be acquired by long practice. It consists in a steady, yet soft and pliable hand, whose sensibility is so nice, as to enable him to hit the precise moment when it becomes necessary to give or to take. This operation does not by any means require strength, but delicacy; and yet the horse is so sensible of it that he instantly obeys.

When the horse has thus been wrought up into a proper position, and has acquired a firm, and determined, and easy action in his paces, in going forwards to the right and left, and on circles, it is time to proceed to render him still more supple in the shoulders, by the exercise, or lesson, of the *epaule en dedans*, or shoulders turned inwards, which is, perhaps, the most important lesson of any, and that upon which all the rest in a great measure depend. For this purpose, the head of the horse must be wrought up into the proper position by the play of the rider's hands, and the bend must be procured in the manner formerly described, and that principally in the joint next to the head. The legs of the horseman must, at the same time, be prepared to act along with the hands in giving the necessary aids. When the horse has been rode in this position, to the right and left, until he goes with perfect steadiness and freedom, the rider should walk him forwards to the right, and endeavour, almost imperceptibly, to place him so, that the hinder feet keep the straight line of the wall, while his fore feet come out about a foot and an half from the wall, inwards beyond the line and towards the centre. This is what is called moving on two *pistes*; by which is meant, that the fore and hinder parts of the horse do not follow, but describe two different lines; a thing which never ought to be attempted until the horse is sufficiently suppled, and made perfect in his forward motions. In order to effect the action of the *epaule en dedans*, the rider must play with the outward rein in his right hand, crossing it over towards the left a little backwards. By these means two advantages are gained. In the first place, from the feeling of the mouth-piece, or bit, pressing on the bars, the horse is made acquainted with the side towards which he is to go; and in the second place, the neck is bent, and the rein which presses upon it towards the left side compels him to bring the right shoulder forwards, and to cross the inward leg over the outward one; and, to this end, the rider should also press his right leg to the horse's side, which brings in his shoulders.

and preserves his proper position. Care must be taken that the horse's inward leg pass over the outward one without touching it. The crossing over of the inward leg, therefore, must be helped, by crossing the inward rein towards and over the outward one, every time that the outward leg comes to the ground, in order to lift and help the inward leg over it.

After the horse has become familiarly accustomed to this motion, you should then proceed to effect, by degrees, the same crossing in his hinder legs. By bringing in the fore legs, you will, of course, engage the hinder ones in the same work. If they resist, the rider must bring both reins more inwards, and, if necessary, put back also, and approach his inward leg to the horse. Should the horse throw out his croup too far, the rider must bring both reins outwards, and if absolutely necessary, he must also delicately make use of his outward leg for a moment, in order to replace the horse properly. It must be observed, that the croup should always be considerably behind the shoulders, which, in all actions, must go first; and the instant the horse pays obedience to the aids, the rider must place his hand and leg again in their usual position. Throughout the whole of this lesson, attention must be paid to keep the horse exactly on the prescribed line, by giving and taking with the reins, and giving the aids properly and delicately with the legs when necessary. In this lesson, as indeed in all others, the corners must not be neglected; the horse should go well and thoroughly into them, both with his head and his croup. Bring his fore parts into them, by crossing over the inward rein towards the outward one, but without taking off from the proper bend of the head, neck, and shoulders; and bring them out of the corner again, by crossing over the outward rein towards the inward one. These uses of the reins have also their proper effects upon the hinder parts.

In every exercise, the rider must carefully avoid all unsettled motion or wriggling with his legs; than which nothing can be more ungraceful in itself, more detrimental to a man's seat, more destructive of the sensibility of a horse's sides, or more inconsistent with all true, steady, and determined action. It is impossible upon the whole, for a man to be too firm, settled, and gentle on horseback. Every thing should be effected, if possible, by the reins only, in an easy, graceful, still manner, without suffering the horse either to throw himself over too fast, or to go lazily over to the other hand. The legs should not be used unless the hands fail, and then with the utmost gentleness. After the horse has been taught to go freely, on this lesson, to the right, the rider may change to the left; and the exercise is then performed in the same manner as above described, only reversing the use of the hands. At first, the figures worked upon should be large, and they may afterwards be contracted by degrees, while the cadenced pace must be accordingly augmented. In order that the horse may not become accustomed always to go along the wall, he should be rode in the same manner across the course, and exercised alternately to the right and left, until he has acquired a perfect facility in crossing his legs.

This lesson of the *epaule en dedans* is among the most useful exercises of the manege. It tends to supple and lighten the horse's shoulders; brings him upon his haunches; gives him a graceful carriage; and makes him acquainted with the proper aids. When he has been taught to do this freely and properly to the right and to the left, the rider will find him become so docile and so pliable, that he will have little or no difficulty in performing all the other exercises of the manege.

In performing this lesson, the horse must necessarily have acquired considerable sensibility in his mouth, as well as suppleness in his limbs and joints; and this, therefore, is perhaps the proper time to teach him to back; but the rider should not neglect, every time he stops, to back a few paces, and then put the horse forwards by little at a time, by approaching both legs gently to his sides, with an equal degree of pressure, and playing with the bridle. In backing, if the horse attempts to rear, push him out immediately into a full trot. The pressure with the legs, which is sometime necessary in backing, in order to collect the horse, and prevent him from going too much on his shoulders, ought to be very small, and to be taken away the moment that he puts himself sufficiently upon his haunches. In all his exercises, indeed, the horse should be kept, to a proper degree, upon his haunches, with his hinder legs well placed under him, which will render him pleasant to himself and his rider, light in hand, and ready to execute whatever may be demanded of him with facility and vigour.

When the horse has been sufficiently practised in the lesson of the *epaule en dedans*, he should next be made to traverse, or passage, with his head to the wall, and his croup to the wall. In the lesson of the head to the wall, the fore parts of the horse are more remote from the centre, and consequently go over more ground; in that of the croup to the wall, the hinder parts are more remote from the centre, and consequently go over more ground. In both, as in all other lessons, the shoulders must go first. The motion of the horse's legs in passaging to the right is the same with that of the *epaule en dedans* to the left, and so *vice versa*; but the head is always bent and turned differently. In the *epaule en dedans*, the horse looks the contrary way to that which he goes; in passaging, he looks the same way he is going. The directions for executing this lesson are so similar to those given for the *epaule en dedans*, that we deem it unnecessary to repeat them. We must observe, however, that in the execution of all lessons, and more particularly in the one of which we are now speaking, the equilibrium of the riders body is of the greatest use. The body must always go along with the horse; when to the right, to the right; and when to the left, to the left. When the horse has been taught to perform this lesson easily at a slow pace, he may be brought to a gallop, which is the most pleasant motion, and that which best shews off the figure of a horse. The rider, however, must be very quiet and exact in his changes. The horse will then, with the proper aids, go perfectly united, use his haunches, and make his cadences with regularity.

After the rider has put his horse through the lessons above described, with the trench, or snaffle, and thus rendered him supple in the shoulders, pliable in the haunches, and light in hand, he may then proceed to use the bit. The advantages of the bit are chiefly these; It is more convenient for the rider, and produces a more certain effect; and it gives the horse a fine carriage, by making him collect his strength, and throw himself on his haunches. No bits, however, should be used, until the riders are firm and the horses bend well to the right and left; and, even then, with the greatest care and gentleness. The old custom of using strong and heavy bits is now abandoned in all good schools, for this reason, that they pull down the horse's head, obstruct the action of the fore parts, and harden the hand of the rider, as well as the mouth of the horse. Some horses, when first the bit is placed in their mouths, if great care be not taken, will put their heads very low. This fault must be corrected by raising your right hand with the bridoon in it, and playing, at the same time, with the bit in the left hand, giving and taking.

It is now time that we should advert to the method of mounting a horse, and to the proper position of the rider on horseback. In mounting, the man should approach the horse gently, near the left shoulder, and take up the reins. The bridoon-rein should be taken up first, the left rein passing along the palm of the left hand, through between the fore-finger and thumb; and the bit reins should then be drawn over the finger next to the little finger. The whole reins should then be laid over each other, and grasped firmly with the whole hand, and with the thumb pressed down upon them, in order that they may not slip through the fingers. The right bridoon-rein should be held, at least for some time, in the right hand. The rider must then take an handful of the mane in his bridle hand, then put his left foot softly into the stirrup, and raising himself up, rest a moment on it with his body upright, and afterwards pass his right leg clear over the saddle, without rubbing against any thing, and seat himself gently down. The reins must not be taken up too short, lest it should make the horse rear, run, or fall back, or throw up his head; but they ought to be of equal length, and neither tight nor slack. Soldiers should be instructed to mount and dismount equally well on both sides, which may be of great use in times of hurry and confusion. The same precautions are to be used in dismounting as in mounting.

The rider should be placed upright in the saddle, with his body rather back, and his head held up with ease, but without stiffness. The breast should be pushed out a little; the thighs and legs turned in without constraint, so that the fore part of the inside of the knees may press on the saddle, and the legs hang down easy and naturally, the feet being parallel to the horse's sides, neither turned in nor out, only that the toes should be kept a little higher than the heels. By this position, the natural weight of the thighs has a proper and sufficient pressure of itself, and the legs are in readiness to act when necessary. For this purpose they should always be near to the horse's sides, but without touching and tickling them. The body must be kept easy and firm when in motion. The left elbow should lean gently against the body, a little forwards, and the hand, in general, ought to be of equal height with the elbow. But, as the mouths of horses are different, the situation of the hand also must occasionally differ. A leaning, low, heavy fore-hand requires a high hand; and a horse that pokes out his nose, a low one. The right arm must be placed in symmetry with the left; only let the right hand be a little more forward or backward, as occasions may require. The left hand, which holds the reins, must be kept clear of the body, about two inches and a half forward from it, and immediately above the pummel of the saddle. The nails should be turned opposite to the waistcoat buttons, and the wrist a little rounded with ease; a position not less graceful than ready for slackening, tightening, and moving the reins from one side to the other, as may be found necessary. The joint of the wrist must not be kept stiff, but easy and pliable, yielding and taking occasionally when requisite. A firm and well-balanced position of the body is of the utmost consequence, as it affects the horse in every motion; on the other hand, the want of it is the greatest detriment to him, and an impediment in all his actions. The body must always go along with the horse, and the leaning, therefore, should always be towards that side to which the horse moves.

It is very requisite in horsemanship, that the hand and legs should act in correspondence with each other in every thing; the latter being always subservient to the former. Upon circles, the outward leg is the only one to be used, and that only for a moment at a time, in order to make the horse go true, if he be false; and as soon as that is done, it must be taken away again immediately. If the horse is lazy, or any way retains himself, both legs must be used, and pressed to his sides at the same time together. In general, however, the less the legs are used the better; very delicate riders never want their help; and horses so dressed are much superior to all others. They obey the smallest touch on the rein, or the least weight of the body imperceptibly thrown on the one side or the other, as may be necessary. The horse and man thus go perfectly together, and seem one and the same.

By the term *outward* is understood the side which is more remote from the centre; and by *inward* is meant the side next to the centre. The inward rein must be the tighter on circles, and the outward one crossed over a little towards it, in order that the horse may bend and look inwards. In reining back, the rider should be careful not to use his legs, unless the horse backs on his shoulders; in which case, they must both be applied gently at the same time, and correspond with the hand. If the horse refuse to back at all, the rider's legs must be gently approached, until the horse lifts up a leg as if to go forwards; at which time, when that leg is in the air, the rein of the same side with the leg which is lifted up will easily bring that same leg backwards, and accordingly oblige the horse to back. If the horse attempts to rear, the legs must be instantly removed, and the reins slackened.

To work a horse in hand is not thought to be a very difficult operation, yet it requires a certain degree of activity, delicacy of hand, a quick eye, and good temper and judgment. In explaining the method of working in hand, we shall suppose that the horse moves to the right all the way through. Two people on foot should be employed in this operation; one, indeed, may do, if he be a handy person; but two are much better at first. One of these people holds a long string, and, in some lessons, two long strings, fixed in a manner which shall be presently explained, and a *chambriere*, standing at some distance from the horse. The other person stands near the horse, holding the reins of the snaffle, and a hand whip, to keep the horse off from him when necessary. Girt a pad, with a crupper to it, upon the horse. The pad must have a large ring upon the centre of the top of it, and about four inches lower down, on each side, a smaller one. On the top of the pad, a little more forward than the great ring, there must be a small strap and buckle, which serve to buckle in the snaffle reins, and to prevent their floating about, and the horse entangling his legs in them in the longe. Horses must never be worked in hand with any thing in their mouths but a large, thick, plain, running snaffle. A bridle is too ticklish, and would spoil the horse's mouth, unless it be in the hands of a very able master. The eyes of the snaffle should be large; and on the head-stall, about the height of the horse's eye, should be fixed a ring on each side.

The person with the *chambriere* holds a long string, about eighteen feet long, which must be of a proper thickness, and smooth, so as to allow it to run freely. This string, in the *epaule en dedans* to the right, is buckled to the right-hand small ring on the pad, where the reins of the running snaffle are first fixed; from thence it passes through the right eye of the snaffle, and from that to the right-hand small ring on the head-stall, and through the large ring on the top of the pad, into the hand of the person who holds the *chambriere;* who, by means of this string, bends the horse to the right, and brings in his shoulder; following him on his right side, and tightening and loosening the string, as he finds it necessary. If the horse's fore-hand is high, and well placed, it will not be necessary to pass the string through the ring upon the head-stall. At the same time, another person, standing near the horse, the snaffle reins separated, and the right one tied loose on the right side, leads him on with the left rein of the snaffle in his hand, walking near his head, and taking care to keep the shoulders in their proper place, and not to take off from the bend to the right, which is occasioned by the string in the other person's hand, who will find it most convenient, when working on this lesson to the right, to hold the string in his right hand, and the *chambriere* in his left, and so *vice versa.* These he must make use of, and keep himself more or less upon the flank, centre, or rear of the horse, as he finds necessary. In the changes from right to left, in the *epaule en dedans*, the person nearest the horse must be quick in getting on the horse's left side; and the person with the *chambriere* must do the same; the former coming round by the horse's head before him, and the latter round by his croup behind him; and so, *vice versa*, to the left. In the head, and in the croup, to the wall, both the men are already properly placed for the changes.

To work in hand, the head and the croup to the wall, two strings, fixed as above described, (only that they must not come at all through the large ring on the pad, but from the small rings on the head-stall, immediately into the hand of the person who holds the *chambriere*,) must be used, one on each side. One string, indeed, might do; the right one, in working to the right, and the left, in working to the left, But two are much better, and often necessary to keep the horse in a proper position. These two strings must be buckled together, and meet in the hand of the person who holds the *chambriere*, and who is on the left side of the horse. The snaffle reins must also be joined, and the person near the horse, who holds them, must likewise be on the left side of him, and near his shoulder, holding the right rein of the snaffle the shortest, to bend him that way, (as does also the right string, kept the tightest in the other person's hand,) and making use also of the left rein when necessary, to keep the horse in a proper position, and to guide him occasionally, as if he was upon him; and never so as to take away from the bend.

With due care and patience, horses will not be very long before they work well in hand; though, indeed, never so truly and delicately as under a good rider. When horses become free and familiar with this method of working in hand, it should be done by degrees on all paces, fast and slow, but always without hurry or confusion. There is nothing which determines them better than working them in hand, when it is well done. When the horse has a rider on him, only one string is necessary to be held by the person on foot. It must be fixed, in the first place, like a running snaffle, to the skirts of the saddle, from whence it goes through the eye of the snaffle into the hand of the person on foot, after having passed under the horse's jaw.

To *piaffer*, without any rider, on square, and all other figures, advancing gently, and going well into the corners, is a very good lesson. One man must stand exactly before the horse, with his face to him, holding the two eyes of the snaffle, and keep the horse advancing gently, by going backwards himself. The man with the *chambriere* must stand behind the horse, and animate him, or not, as he finds necessary. It is useful also sometimes to back the horse in this manner, which may likewise be done on all figures. The degree of vivacity or dulness in the horse must determine how the man with the *chambriere* is to act, and where he is to place himself, when the horse is going on the *piaffe*, or backing. Horses worked well in hand look particularly well in coming up the middle, and backing there on the *piaffe*, as also in the *piaffe* in one place, both bent and straight, animated properly, and kept in a good position; their mouths being properly played with and humoured.

A horse, when well taught, may be worked (and it is then the best way,) by a single man, with long reins and a *chambriere*, without any other person to assist him. All airs in hand are to be worked so, whenever the animal has become supple and obedient. When it is well done, it has a masterly active appearance, and is always very useful in suppling and determining horses; but there is no doubt that a good rider mounted, who possesses a sensible hand, and feels every motion of the horse, must act with more precision, delicacy, and exactness.

If the horse has been sufficiently suppled and determined, and made perfect in the previous lessons above described, he may (if he has the proper disposition for it,) be taught to perform all the high airs, which were so much in vogue in the old school: The curvets, demi airs, groupades, ballotades, and capriols. In teaching these, the pillar is generally used. But our limits will permit us to do little more than merely define and explain these artificial airs.

The action of the *terre-a-terre* is a movement forwards, similar to the gallop, which is the foundation of it; only that in *terre-a-terre*, the rein of the cavesson must be drawn within the volte, and the horse aided by the rider's outward leg, which puts him on his haunches, constrains his hind-legs, keeping them within the volte, and leaving the others free. The action of the *curvet* is similar to that of *terre-a-terre*, with this difference, that in curvets the horse makes a little leap, in which, when he raises his fore-legs, his hind ones fall, and all his four legs are then in the air at the same time, as also when he raises his hind-legs, and his fore-legs fall. In curvets upon the voltes, the shoulders of the horse are chiefly worked, and the croup very little. The *demi-air*, or *demi-volte*, is also founded upon the *terre-a-terre;* but in the former, the fore parts of the horse are more raised than in the latter, in which he goes more low and near the ground, and his action is more quick and pressed. The *groupade*, or *croupade*, is a leap, in which the horse pulls up his hind legs, as if he drew them up into his body. The *balotade* is a leap, in which the horse offers to strike out with his hind-legs, but does not, showing only the shoes of his hind-feet. The *capriol* is also a leap, in which, when the horse is at the full height of it, he yerks or strikes out his hind-legs, as near and as even together, and as far out, as he can stretch them.

For the method of teaching a horse to perform these high airs, we must refer our readers to the works mentioned at the end of this article.

A horse should be taught to leap by degrees, beginning with small leaps, and increasing them gradually as the horse improves. The rider must keep his body back, raise his hand a little, in order to help up the fore-parts of the horse, and be very attentive to his balance, without raising himself in the saddle, or moving his arms. It is best to begin at a low bar covered with furze, which pricking the horse's legs, if he does not raise himself sufficiently, prevents his contracting a sluggish and dangerous habit of touching. To prevent horses from coming too near the bar, two planks should be placed under it, of the breadth of the space between the pillars on which it is fixed. These planks should meet and join at the top, under the bar, about two feet high from the ground, and project about two feet at the bottom. The bar should be placed so as to run round when touched. Horses should be accustomed to come up quietly to every thing they are to leap over, and to stand coolly at it, for some time; and then to raise themselves gently up, and go clear over it, without sloth or hurry. When they leap well standing, they should then be used to walk gently up to the leap, and go over it without first halting; and after that practice has become familiar to them, the same should be repeated in a gentle trot, and so by degrees faster and faster, until they become accustomed at length to leap flying in a full gallop.

Horses, particularly those designed for service, should also be accustomed to swim. A very small portion of strength is sufficient to guide a horse in the water, where they must be permitted to have their heads, and be as little constrained as possible. In crossing rivers, the horse's head should be kept against the current; in going down the stream, the straighter the horse is the better. A horse is with difficulty turned in the water; and, therefore, it should be done very gently and carefully.

In order to teach horses to stand fire, and to bear the sound of drums, and all other noises, they must be accustomed to it by degrees in the stable at feeding time; by which means they will soon cease to be frightened at any thing of the kind. As it is necessary that all troop horses should stand quiet and still when they are shot from, this must also be taught them by degrees, and with patience, coolness, and temper. To use a horse to fire-arms, first put a pistol or carbine in the manger with his feed; then use him to the sound of the lock and the pan; after which, when you are upon him, show the piece to him, presenting it forwards, sometimes on one side, sometimes on the other; then proceed to flash in the pan, and afterwards put a small charge into the piece, augmenting it by degrees to the quantity which is commonly used. If he appears uneasy, walk him forward a few steps slowly, then stop, back, move forwards, stop again, and caress him. These, and all other things which are requisite, in order to make a horse perfectly steady in the field, may be easily taught by good judgment, patience, and gentleness; and it is impossible to be too circumspect in chastising a horse upon these occasions; for, instead of making him steady, it will frequently render him only more suspicious and more timid. An excellent writer on horsemanship has remarked, that whenever you see a man beating any animal, you will almost always find that the man is in the wrong, and the animal in the right. Of all bad tempers and qualities in horses, indeed, those which are occasioned by ignorant riders and harsh treatment are the most common and the worst. Patience and science are the best means of reclaiming a wicked horse; mere force, combined with want of skill and temper, will only tend to confirm him in vicious habits. The coolest and best-natured horseman, *cæteris paribus*, will always succeed best. See the works on horsemanship by Grison; La Broue; Pluvinel; Sir William Hope of Kirkliston; the Duke of Newcastle; Bourgelat; Rossermini; the Earl of Pembroke; Berenger: Le Vailant de St. Dennis; De la Gueriniere; Thompson; Köllner; Beyer, and Marchand. (*z*)

MANGANESE. See Chemistry, and Mineralogy.

MANGEEA, or Mangya, is an island in the South Pacific Ocean, discovered by Captain Cook in 1777. It is about five leagues in circuit, and of a moderate and pretty equal height. It is situated in W. Long. 158° 2′ 45″, and S. Lat. 21° 56′ 45″. See Cook's *Third Voyage*, vol. i.

MANHEIM is a city of Germany, in the Electorate of Baden, situated at the conflux of the Neckar and the Rhine. It is divided into four quarters, one of which contains 20 divisions, and the other 28. Some of the streets are planted with rows of trees. "The streets regularly constructed," says Catteau, "houses executed with taste, public edifices of an imposing character, sumptuous churches, fountains decorated with elegance, and a very extensive palace, render Manheim one of the finest towns in Germany." The elector's palace, which was greatly injured by the bombardment of the city, in 1795, the theatre and the physical cabinet having been devoured by the flames, is a noble building, and contains a gallery of paintings, cabinets of antiquities and natural history, and a library with 60,000 volumes. The custom-house is a magnificent stone building, like a palace, and has shops under the colonnades which surround it. The observatory is an interesting building, having a spire 108 feet high, built with much skill. The other buildings and establishments are, the convent of the Augustines; the convent of the Capuchins; the Cidevant church of the Jesuits, a very superb building; the German parish church; the Salle de spectacles; the arsenal; the foundry of cannon; the mint; the house of correction; and the bridges over the Neckar and the Rhine. The fortifications of Manheim have been razed, but will probably be again renewed.

The principal literary establishments in the town are, an academy of sciences; a society for German literature; an academy of painting and sculpture; a meteorological society; a military school; and a school of surgery. The principal manufactures of the city are those of tobacco, ribbons, shawls, linen cloths, and plying cords. There is also an extensive bleaching ground, and tanneries.

At the distance of some leagues from Manheim is the chateau of Schwelzag, with its vast gardens, celebrated for its tomb of Ninus, the temple of Apollo, the marble bath, the statue of Janus and his grotto, the obelisk, and the temple dedicated to botany.

Population about 23,000. East Long. of the obsertatory 8° 28′ 0″. North Lat. 49° 29′ 18″. See Catteau de Calleville's *Voyage en Allemagne*, &c. tom. i. p. 146.

MANICHEES, the name of a sect of heretics, who received their name from Manicheus, a Persian, about the year 277. They resembled, in many particulars, the Gnostics, of whom we have given an account in our article ECCLESIASTICAL HISTORY.

MANILLA. See PHILIPPINE ISLES.

MANNA. See MATERIA MEDICA.

MANOMETER, or MANOSCOPE, from *μανος, rare*, and *μετρον, a measure*, is an instrument for measuring the rarefaction of elastic fluids, whether occasioned by variation of temperature or pressure. An instrument of this kind has been described in our article BAROMETER, under the name of Boyle's Statical Barometer. See an account of General Roy's manometer, in the *Phil. Trans.* for 1777, p. 689; also Varignon, *Mem. Acad. Par.* 1704, p. 300; Sir H. Davy in Nicholson's *Journal*, 8vo. vol. iv. p. 32; and Gilbert's *Journal*, vol. xv. p. 61. See also our article SYMPIESOMETER, and the *Edinburgh Philosophical Journal*, No. I.

MANSFIELD, a town of England in the county of Nottingham. It is agreeably situated on the river Maun, near the foot of the ridge of hills which separate it from Sherwood Forest. It consists of two good streets, and three smaller ones, which are old and irregular. The church is an ancient and commodious structure, and there is here a respectable free school, with two scholarships at Jesus College, Cambridge, founded by Queen Elizabeth, and a charity school for 36 boys. The principal trade of the town consists in corn and malt. It has considerable manufactories of stockings and thread, and there are several fine freestone quarries in the neighbourhood. Mansfield contains five cotton mills, on an extensive scale, one of which has 2100 spindles, and employs 160 persons. No fewer than 700 frames are employed in working stockings and gloves. There is also an iron foundery, which has an extensive trade. The Presbyterians, Calvinists, Quakers, and Methodists, have all neat and commodious places of worship. The other establishments at Mansfield are, a theatre, a coffee-room, a bowling-green, and a cold-bath. The population of the town and parish, in 1811, was 1427 inhabited houses, 1,603 families, 1,337 families employed in trade and manufactures, and 6,816 inhabitants. See the *Beauties of England and Wales*, vol. xii. part I. p. 374.

MANSLAUGHTER. See LAW.

MANTUA, an ancient city of Italy, about 220 miles north-west from Rome, is a regularly built and well-fortified town, about four miles in circumference. It is beautifully situated on the banks of the river Mincio, which swells into two lakes, one above and the other below the city. In point of antiquity it may be considered as superior to Rome; and is represented by Virgil (Æneid x. 198.) as having existed in the time of Æneas. After the fall of the Roman empire, it experienced all the vicissitudes of the middle ages; and, like the other great cities of Italy, became at length a free and independent state. Afterwards it became subject to one of its own powerful families, the Gonzagas, who governed it under the title of dukes, but with the authority of sovereigns, about 200 years; but the last of these princes, having taken up arms against the Austrian interest, was driven from his dominions, and died in exile at Padua, in 1708. Hitherto it had attained considerable prosperity, and was supposed to contain 50,000 inhabitants. But, at the period of the Austrian invasion, its independence was overthrown, its riches made the spoil of the victors, and many of its antiquities defaced or carried away. During the war which followed the French revolution, it was twice subjected to all the horrors of a siege, (in 1796 by the French, and 1799 by the Russians,) and was finally annexed to the Italian republic. It has again returned to the jurisdiction of Austria, and is at present subject to the Archduchess Maria Louisa, late Empress of France. Its streets are straight and spacious, and it contains several handsome squares and edifices. Giulio Romano, a disciple of Raphael, and an eminent architect as well as painter, devoted his talents to the embellishment of Mantua; and his house, erected by himself, is still pointed out to strangers. His style of architecture is considered as distinguished by strength and majesty, though sometimes too massy and ornamental. Among the principal public buildings are the Corte, with its halls; the Palace of Justice; the Palace of Gonzaga; one in the suburbs called, on account of its form, the palace of T; and the cathedral, which is a beautiful and regular edifice, built nearly on the same plan as Santa Maria Maggiore at Rome. It formerly contained a statue of St. Anselmo, the patron of Mantua, as large as life, and formed of massive silver, but for which the French, when masters of the place, substituted one of wood. The church of St. Andrew is also deserving of notice, which is painted all over in a beautiful style, and contains several very fine pictures. There is a university, which was founded in 1625; and an imperial academy was erected by the Austrian government, which contains an excellent collection of antiquities. Among these the most interesting object was the well-known bust of Virgil, which was supposed to have belonged to a statue of the poet which once stood in one of the squares of the city, but which was thrown into the lake by a barbarous chieftain named Carlo Malatesta. The head of this statue was recovered by the Duke Vespasian, in 1580, and afterwards placed in the Academy by the Austrians, where it remained till the year 1797, when it was carried off by the French, with the most valuable of the other articles. This distinguished poet was born in the vicinity of Mantua; and his little farm appears to have been situated at the foot of the hills, near the village of Valleggio. The Mantuans had planned a public garden at Pielde in honour of the poet, in the centre of which his statue was intended to be placed; but the inclosures and plantations were completely destroyed during the second siege which it sustained in the revolutionary war. North Lat. 45° 9′ 16″. East Long. 10° 48′ 12″. See Eustace's *Classical Tour in Italy*. (*q*)

MANURE. See AGRICULTURE *Index*.

MAOUNA, or MASSACRE ISLAND, is an island in the Pacific, discovered by Bougainville, and visited by La Perouse in 1787. It is situated in East Long. 189° 1′, and South Lat. 14° 22′. See La Perouse's Voyage, vol. ii.

MAPS, METHOD OF CONSTRUCTING. See GEOGRAPHY.

MARACAIBO. See CARACCAS.

MARAGNAN. See BRAZIL.

MARALDI, JAMES PHILIP, an assiduous astronomer, was born at Perinaldo, in the county of Nice, in the year 1665. He was called to Paris in 1687, by his uncle, the celebrated Cassini, under whom he pursued his studies. He constructed a catalogue of the fixed stars, which is still in MS. In 1700 he assisted at the prolongation of the meridian of Paris to the north; and at Rome, Clement XI. availed himself of his knowledge in the correction of the calendar. In 1718 he was employed, with three other academicians, in prolonging the meridian of Paris to the south. He died on the 1st of December 1729, in the 65th year of his age. His memoirs, published among those of the Academy of Sciences, amount to no fewer than 130. They are almost all astronomical and meteorological. His eloge will be found in the Memoirs of the Academy for 1729.

MARANHAO. See Maragnan.

MARANON. See Amazons.

MARATHON, the name of a small village in Attica, celebrated by the famous battle of that name, in which the Persian army was totally defeated by the Athenians. A full account of this battle will be found in our articles Athens, and Greece. A very interesting account, with several views, and a plan of the field of battle at Marathon, will be found in Dr. E. D. Clarke's *Travels*, vol. iv. p. 12, &c.

MARBLE. See Mineralogy.

MARBLES, Arundelian. See Arundelian.

MARBLES, Elgin. See Athens, and Sculpture.

MARBLES, Ægina. See the *Journal of the Royal Institution*, vol. vi. p. 327; the *Edingburgh Philosophical Journal*, No. I.; and Sculpture.

MARCHE. See France.

MARCIANO, Battle of. See France.

MARENGO, Battle of. See France.

MARGARETTA, an island in the Caribbean Sea, belonging to the captain generalship of the Caraccas. It consists of two peninsulas, the easternmost of which is the largest, connected by a narrow isthmus. Assumption, the capital, is built almost in the centre of the island. The strait which separates it from the peninsula of Araya is 8 leagues wide. The island lies between 63° 50′ and 64° 30′ West Longitude, and 10° 50′ and 11° 10′ of North Latitude; and has a population of 14,000, viz. 5500 whites, 2000 Indians, and 6500 slaves and free people of colour. See Depon's *Travels in South America*; and our article Caraccas.

MARGATE, a sea-port town of England, in the county of Kent, and one of the most fashionable and best frequented watering places. It is situated on the northern extremity of the island of Thanet, within a small bay in a breach of the cliff. Since the rebuilding of the pier with stone in 1787, Margate has increased rapidly in importance. It consists of a number of small and irregular streets, with many neat and excellent modern buildings, particularly those in Cecil Square, Hawley Square, Neptune Square, and Union Crescent. The church, which stands on an elevated spot on the south-east side of the town, is spacious, and contains several ancient sepulchral monuments. There are also chapels for the Baptists, Catholics, Wesleyans, and the Huntingdonites. The principal charitable establishments are, a general sea-bathing infirmary, erected in 1792; drapers' hospital; and a charity school for 40 boys and 40 girls. The chief public buildings are, the assembly rooms at the south corner of Cecil Square; a theatre in the east corner of Hawley Square, erected in 1787, at the expence of 4000*l*; and bathing rooms, situated on the western side of the High Street. The pier, which is furnished with a rampart breast high, is the fashionable promenade. The town and harbour are defended with a new fort, mounted with heavy guns. There are several libraries in Margate; warm, vapour, and temperate baths, and excellent bathing machines. The town is governed by a constable, deputed by the governor of Dover castle. The trade of Margate consists in sending corn and fish to the metropolis; in importing coals from Newcastle and Sunderland, and timber, iron, tar, tin, and hemp from Memel and Riga. No fewer than 70 packets, hoys, boats, &c. are employed in carrying passengers to London. Within a mile and a half of the town is a place called Dandelion, a rural spot where public breakfasts and dinners are occasionally given.

The population of the town and parish of Margate, in 1811, was 1229 houses, 1281 families, of whom 325 were employed in trade and manufactures, and 6126 inhabitants. See the *Beauties of England and Wales*, vol. viii. p. 956.

MARIUS. See Rome.

MARLBOROUGH, Duke of. See Churchill.

MARIGNANI, Battle of. See France.

MARLBOROUGH, a borough and market-town of England, in Wiltshire. It is situated on an eminence, at the bottom of which runs the river Kennet, and consists principally of one long street running from east to west, and forming part of the great road from London to Bath. The houses, some of which are of stone, but the greater number of brick and wood, are irregularly built. Part of the street has a piazza projecting before the shops; and at the eastern extremity of the street is an ancient and singularly constructed market-house. The other public buildings are, the old church of St. Mary; St. Peter's church, with a lofty square tower; several meeting-houses for the dissenters; a handsome building for the charity school for 44 children; and a good prison. Since the formation of the Kennet and Avon canal, which passes within 4 miles of the town, coals and other articles have been imported; and large quantities of grain from the surrounding valleys have been sent to Newbury, Reading, and London. In 1811, this borough contained 445 houses, 649 families, of whom 405 were employed in trade and manufactures, and 2579 inhabitants. See the *Beauties of England and Wales*, vol. xv. part ii. p. 673.

MARLE. See Agriculture *Index*, and Mineralogy.

MARLOW, Great, a town of England, in Buckinghamshire, is situated on the banks of the Thames, over which there is a good wooden bridge, built by subscription in 1798. It consists of two principal streets in the form of the letter T, and three smaller. There are some good houses in the High Street. The church is an ancient and spacious building, with a wooden tower. The market-house is a new and elegant building, erected at the expence of Mr. Williams, from designs of Mr. Wyatt. The charitable establishments are, two charity schools, and six alms-houses. The manufactures of this town are paper and black silk lace. There are large works for copper, brass, and iron wire, and mills for making thimbles, and pressing oil from rape and lintseed. Its principal trade is in coals and timber, which are sent down the Thames. The town has, no doubt, suffered considerably from the removal of the Royal Military College to Sandhurst, in Berkshire. The borough sends two members to Parliament.

The population of the borough, exclusive of the parish, was, in 1811, 468 houses, 520 families, of whom 116 were employed in trade, and 2799 inhabitants. See the *Beauties of England and Wales*, vol. i. page 377.

MARMONTEL, John Francis, an eminent French writer, was born at Bort, a small town in the Limosin, in the year 1723. His father was in humble circumstances, and had a large family of children, of whom John Francis was the eldest. His mother possessed talents and accomplishments superior to her rank in life; and through her influence he was sent to the Jesuits' college of Mauriac, where he was initiated in classical studies and rhetorical exercises. At the age of fifteen, his father placed him with a merchant at Clermont; but having no inclination to prosecute this profession, he immediately quitted it, and applying for admission to the college of Clermont, he was received into the philosophical class. His moderate wants were soon after supplied, by the small emolument derived from some scholars who were committed to his care. In the second year of this occupation his father died; and he undertook the paternal charge of the destitute family. He soon after went to Toulouse, where he engaged as teacher of philosophy in a seminary of the Bernardines. The academy of Floral Games at Toulouse being in the habit of giving annual prizes for literary compositions, Marmontel wrote an ode as one of the competitors, and was much mortified that it did not obtain the prize. From this tribunal he made an appeal to Voltaire, who returned his performance with liberal applause, and presented him with a copy of his works. Being highly gratified by this condescension from so great a man, he proceeded with ardour in his career, and obtained the prizes of several successive years. As his reputation increased, he sometimes supplied the place of the professor of philosophy, and was made an adjunct in the academy.

By the advice of Voltaire, he resolved to try his fortune at Paris, where he arrived in 1745, and devoted himself to the study of dramatic poetry. In the mean time, he wrote a poem which obtained a prize from the French Academy; and in conjunction with a literary friend, he published a periodical paper which had little success. All his efforts, however, were inadequate to preserve him from indigence, when a fortunate introduction to a lady, who engaged him to educate her grandson, relieved him from his embarrassments, and procured him admission into a select and agreeable society. His first tragedy, entitled *Denis le Tiran*, was brought upon the stage in the month of February, 1748, and obtained general applause. He now became distinguished in the circles of literature and fashion, and sustained his character as a man of pleasure, first by a connection with Mademoiselle Navarre, the mistress of Marshal Saxe, and afterwards with Mademoiselle Clarion, the celebrated actress. He did not, however, neglect the art to which he was indebted for his reputation. In 1749, he produced his second tragedy, *Aristomene*, which had also great success. His next dramatic performance, the tragedy of *Cleopatra*, was finished and acted in 1750. It was carelessly written, and performed with indifferent success. Another piece, *Les Heraclides*, was represented in 1752, and totally failed.

In the mean time, having ingratiated himself with Madame Pompadour, by some court incense, he took an opportunity of being introduced to that all-powerful favourite, and was graciously received. He hoped, through her influence, to obtain a place in one of the public offices; but as she expressed a wish that he should again try his fortune at the theatre, he complied, and produced *Les Funerailles de Sesastris*. This piece, however, had no better success than the last; but his new patroness consoled him for his disappointment, by the situation of secretary of the royal buildings under her brother, M. de Marigny; and he now took up his residence at Versailles.

At this period he was much connected with D'Alembert and Diderot, whom he assisted in the *Encyclopedie*. His assiduities and services to persons in power at length procured him a pension upon the periodical work called the *Mercure François*. The privilege of the work itself he obtained for a friend of his, M. Boissy, who being once at a loss for original pieces to fill it respectably, applied to Marmontel for his assistance. The tale, entitled *Alcibiades*, composed at a single sitting, was the result of this application; and it was received with so much applause, that the author was encouraged to insert several other tales in the same publication. This was the origin of the *Contes Moraux*, which became so popular throughout Europe. Boissy having died soon after, the *Mercure* was given to Marmontel, who thereupon quitted Versailles, together with his place of secretary of the buildings, and went to reside at Paris, in the house of Madame Geoffrin, in the year 1758. The life of ease and pleasure which he now led was interrupted by a disagreeable circumstance. One Cury, a man of pleasantry, had composed a satire on the Duke d'Aumont, in the form of a parody on a scene in the tragedy of Cinna. Marmontel, who was intimate with him, got the verses by heart, and imprudently repeated them before a party at Madame Geoffrin's. The verses were attributed to him; and as he refused to give up the real author, he was committed to the Bastile on the complaint of the Duke. He was, however, very well treated, and released after a short confinement; but the *Mercure* was taken from him. This was a serious loss; but the multiplied editions of his tales afforded him a handsome sum; and his literary reputation was now so great, that he was in no danger of wanting profitable employment for his pen. After making a tour through the southern provinces of France, in which he paid a visit to Voltaire, he wrote his *Epitre aux Poetes*, which gained the prize from the French Academy, although Thomas and Delille were his competitors. He obtained admission into the Academy in 1763, as successor to Marivaux.

His next literary production, and that perhaps which has conferred the greatest celebrity on his name, was his *Belisarius*. The liberal sentiments which the author had expressed in this work with regard to religious toleration, caused it to be condemned by the doctors of the Sorbonne; but, in the mean time, large editions of it had been dispersed over France and all Europe, and the author obtained a complete triumph. After a pleasant tour to Aix-la-Chapelle and Spa, he returned to Paris, where he became acquainted with the musician Gretry; for whose benefit he wrought up several little little stories into comic operas, to be set by him, which were presented at the theatre with great success. About this time, he quitted the house of Madame Geoffrin, and took up his abode with Mademoiselle Clairon.

On the death of Duclos, in 1772, Marmontel was appointed, without any solicitation, to succeed him as historiographer of France; and he prepared to exercise the duties of this office, by collecting materials for the reign of Louis XV. He also engaged in the composition of the supplement to the *Encyclopedie*, which followed the seven original volumes of that work. When the musical war broke out between the partisans of Gluck and Piccini, Marmontel took part with the latter, and employed himself in accommodating the operas of Quinaut to his Italian style of composition. At the age of fifty four, he formed a matrimonial connection with a young lady of eighteen, from Lyons; and there is every reason to believe that the union was a source of much happiness. About this time, he published his historical romance *Les Incas*; and composed a poem in twelve cantos, *Sur la Musique*, in defence of Piccini, to whom he gave the words of the opera of *Didon*. In 1783, he was elected to the post of perpetual secretary of the French Academy, in the place of D'Alembert. From this period his time was chiefly occupied in composing *eloges*, and other pieces, read before the Academy; and in preparing a complete edition of his works, which had now become voluminous. Under the ministry of M. Lamoignon, keeper of the seals, he was consulted respecting a plan for the improvement of the national education; and he spent much time in drawing up an elaborate memoir on that subject. The dismission of that minister, however, put an end to these labours; and the turbulent scenes which ensued, produced a great change in his circumstances and mode of life. Having been partial from his youth to monarchical institutions, it was not to be expected that he should adopt those revolutionary principles, of which many of his literary cotemporaries became the zealous advocates; indeed, he contemplated with horror those constitutional changes which were meditated by the popular party. He was chosen, however, by one of the sections of Paris, as a member of the electoral assembly; but in consequence of the opposition which he made to a proposal for demanding an unlimited liberty of the press, he lost the confidence of his constituents, and was expunged from the list of candidates to the National Assembly. His income having been greatly diminished by the reforms in the expenditure, and the revolution having begun to assume a violent and sanguinary aspect, he retired, in 1792, with his family, to the neighbourhood of Evreux, in Normandy. A cottage which he purchased at Abloville was his final retreat, where he passed his time in the education of his children, and in the composition of some new works. Among these were some additional *Contes Moraux*, and a *Cours Elementaire* for the instruction of youth, consisting of short treatises on grammar, logic, metaphysics, and morals. He also composed Memoirs of his own life, addressed to his children; a lively and entertaining work, but containing some passages not very well adapted for the perusal of young persons. In the month of April, 1797, he was elected by the department of Eure as their representative to the National Assembly, and was particularly charged with the defence of the Catholic religion. He accordingly pronounced before the Legislative Body a discourse *on the free exercise of public worship*; and he continued to discharge the duties of his office, until the decision which rendered null the elections of his and other departments. He then retired again to his cottage, where he died in the month of December, 1799, of an apoplexy, in the seventy-seventh year of his age.

Marmontel holds a high rank amongst the modern French writers. He possessed a lively and inventive genius, and wrote with great eloquence and command of language. His *Moral Tales*, his *Belisarius*, and *Incas*, are the most popular of his works, and those best known to foreigners. His poetical works are now little read abroad, and seem to be less valued in France than his prose. Besides the works we have already mentioned, there have appeared, since his death, *Memoirs of the Regency of the Duke of Orleans*, printed from his manuscript, in two volumes 12mo. See *Mem. de Marmontel*, and Aikin's *Gen. Biog.*

MARMOT. See ZOOLOGY.

MARNE, one of the north-eastern departments of France, derives its name from the principal river by which it is watered, and was formed out of the districts of Remois, Pertois, and La Brie. It is bounded on the north by the department of the Ardennes, by those of the Aisne, the Seine, and Marne, on the south by that of the Aube, and on the east by that of the Upper Marne and the Meuse. The department is about 33 leagues long, and 30 broad, and its area is 430 square leagues. It produces corn, wine, hemp, and cattle, but its chief wealth is derived from its wines. The wines of the Canton of Sillery are celebrated. The best of the white wines are those of Ai, Hauteville, Epernay and Moreuil, which are called *vins de Riviere*. Among the red wines, called the *vins de Montagne*, the most renowned are those of Verzy and Verzenai. The principal rivers are, the Marne, the Aisne, the Suippe, and the Veste. The chief towns are,

	Population.
Chalons sur Marne,	11,120
Rheims,	30,295
Vitry,	6,995
Epernay,	4,430
St. Menehoult,	3,394

The forests occupy 165,000 acres, one half of which belongs to the state. The contributions, in 1803, were 4,151,188 francs, and the population 310,493. Chalons is the capital.

MARNE, UPPER, one of the north-east departments of France, was formed out of the districts of Bassigny and Vallage. It is bounded on the north by the departments of the Marne and the Meuse, and on the west by those of the Aube and the Cote D'Or; on the south by that of the Cote D'Or and the Upper Seine, and on the east by that of the Vosges. It is about 29 leagues long and 19 broad, and has an area of 331 square leagues. The country is in general level, and abounds in grain and in pasturage. The wooded hills contain iron mines and mineral springs, and its principal trade consists in wood and iron. Wine and hemp are also produced. There are many forges in the neighbourhood of St. Dizier; and near Chaumont, corn and wine are produced most abundantly. The principal rivers are the Marne, the Meuse, and the Aube. The chief towns are,

	Population.
Chaumont, the capital,	6,188
Langres,	7,283
Vassy,	2,170

The forests occupy 378 acres, of which the third belongs to the communes, and the great part of the other two-thirds to the nation. The contributions, in the year 1803, were 2,315,762 francs.

MARPURG, or MARBOURG, the capital of Upper Hesse, is situated on the west side of the Lahn, and is defended by a castle, the former residence of the Landgraves of Hesse. The university, which was founded in 1527, has a fine library. There is also an academy for classical literature, and 3 Protestant Churches. In the Church of St. Elizabeth is a monument of that Saint, and the mausoleum of a Count of Lippe. The manufactures of that place are, serges, camblets, cotton cloth and chocolate. Population 5600. East Long. 15° 43′ 40″, and North Lat 46° 34′ 42″.

MARQUESAS, a group of islands in the Pacific Ocean, extending from 8½° to 10½° North Lat. and from 138¾° to 140½° East Long. Four of them, lying to the south-east, were first discovered in July 1595, by Alvaro Mendana de Neyra, who named them Las Marquesas de Mendoza, in honour of Mendoza, Marquis of Canete, at that time Viceroy of Peru. They do not appear to have been again visited by Europeans till the year 1774, when Captain Cook went in search of them, to ascertain their longitude, and procure provisions. A French navigator, named Marchand, visited them in 1789, and discovered several additional islands to the north-west, which have been called the New Marquesas. These were next observed by an American commander, named Ingraham, who did not land upon them; and the principal information respecting them was obtained by Lieutenant Hergest, in the Dœdalus storeship, which touched at those islands in her way to join Captain Vancouver in 1792. Several vessels, chiefly American, have occasionally visited them, for the sake of procuring provisions; and the commander of one of these, named Roberts, built a small vessel on one of the more southerly islands. But the most correct account of their positions has been given by Captain Wilson, of the missionary ship Duff, who visited them in 1797; and the fullest description of their inhabitants by the Russian commander Krusenstern, who explored particularly the group to the north-west, in the year 1803

The inhabited islands are eight in number, viz. La Magdalena, or Ohittatooa; St. Pedro, Onateaya; La Dominica, or Oheevahooa; (which were all discovered by Mendana in 1595;) Hoodi Island, or Teeboaa, (discovered by Captain Cook in 1774;) Trevennen's Island, or Ooapoa; Rious Island, or Ooahooga; Martin's Island, or Nooaheeva, discovered by Marchand, or by Ingraham, (for the point is disputed among navigators,) about the year 1789.*

Ohittatooa, the most southern island of the group, was the first which Mendana discovered; and was named by him La Magdalena, in allusion to the Romish festival, on which he fell in with it. It was judged to be about six leagues in circumference; and appeared to be populous and fertile. It was reckoned by Captain Cook to be situated in 10° 25′ south latitude, and 138° 50° west longitude.

Ohittahoo, named by Mendana, Santa Christina, is about 3 leagues in length from north to south, and 7 in circumference. It is divided through its whole extent by a narrow ridge of lofty hills, from which various branches run down to the coasts, forming deep and fertile valleys, ornamented with trees, and watered by streams and cascades. On the western side are several bays, one of which, under the highest land, called originally Madre de Deos, but afterwards Resolution Bay, is a safe and capacious harbour, in south latitude 9° 55′ 30″, and west longitude 139° 8′ 40″. This island, though of small extent, yet being best known to Europeans, was selected as a missionary station in 1797.

Onateya, named by Mendana Santo Pedro, lies about 5 leagues eastward of the last mentioned. It is about 3 leagues in circumference, tolerably level, though high land, with extensive woods and pleasant plains.

Ohevahooa, about a league to the north of Ohittahoo, which it greatly resembles in its woody hills and verdant valleys, is about 16 leagues in circumference; and was named by Mendana La Dominica, as having been discovered on the Lord's day. There is no harbour on the south coast; but the natives have always attended at Resolution Bay when any European vessels have lain there, and maintain a friendly intercourse with the inhabitants of that place.

Teebooaa, situated in Lat. 9° 26′, about 5 leagues north from the easternmost point of Ohevahooa, and called by Captain Cook Hoodi Island, has rather a bluff appearance, and is one of the smallest of the group.

Ooapoa, the most southerly of the new Marquesas, called by Hergest Trevennen's Land, is remarkable for two rocky eminences of vast height in the centre, and a rock near the south-east point of the coast, resembling a church with a spire. Its northern extremity is in south Lat. 8° 21′ 30″, and west Long 139° 3[illegible]′. On the south side are several bays, and particularly one near the south west point, named Friendly Bay, where the country appeared populous and fertile.

Ooahooga, to the north-east of the last mentioned, called by Hergest Rious Island, lies in south Lat. 8° 58′ 15″, and in west Long. 139° 13′. It is about nine miles in length, high and craggy at the west end, but provided with two bays on the south side, and is apparently more fertile than the more southern islands of the group.†

Nooaheeva, or, according to Krusenstern, Nukahiwa, the principal island of the whole group, about 24 miles due north from Ooapoa, and 18 north-west from Ooahooga, is about 17 miles at its greatest length, and at the south extremity is in south Lat. 8° 58′ 40″, and in west Long. 139° 41′ 30″. It was named by Hergest Sir Henry Martin's Island; and presents to the navigators several commodious harbours, particularly on the southern coast, of which the most frequented is called port Anna Maria, situated close to the south-east cape. Lofty and barren mountains occupy the centre of the island; and the south coast is a chain of steep and rugged rocks, rendered extremely picturesque by a number of beautiful cascades, one of which, several fathoms wide, falls from a height of 2000 feet. On the west side, the ground is lower and more level, gradually rising towards the central mountains, and several delightful valleys have been observed on all parts of the coast. In these, the grass was found so luxuriant, as to reach above the knee; and the trees (chiefly the cocoa and bread-fruit species,) were apparently 70 or 80 feet high.

There are four uninhabited islands, two of which (called by the natives Mottooaity,) are very small, and lie about 30 miles west by north, from the south point of Nooaheeva. These are commonly called Hergest isles. The other two, named Hiaoo, and Fattoo-oohoo, the former of which is 8 miles in length, are situated about 60 miles north-west from the western point of the same island, and are occssionally visited for the sake of the cocoa-nuts which they produce: These are generally known by the name of Roberts' isles. It is conjectured that other islands might be discovered both towards the north-west and south-east.

Ohittahoo and Nooaheeva, are the best known to Europeans of all the Marquesas; but, both in point of natural productions, and the character of the inhabitants, the whole group bear a near resemblance to one another.

The climate is sultry, but salubrious. The winter or rainy season is of short duration; and ten months frequently pass without a drop of rain. These long droughts occasion a general famine, and give rise to the most horrible outrages among the natives. The south-east trade wind is the most prevalent; but gales from the south-west are occasionally experienced, and continue for a considerable space of time. The tides invariably change every six hours, the flood setting from the east; and at the full and new moon, it is high water between 4 and 5 o'clock. A heavy surf continually breaks upon all the coasts, and vessels find it difficult to procure water from the shore, without the assistance of the natives, who swim with the casks through the midst of the breakers.

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* The three last mentioned, with four or five smaller uninhabited islands, usually called the New Marquesas, are considered by Krusenstern as the discovery of Americans, and proposed by him to be denominated the Washington Islands.

† It is rather singular, that these two last mentioned islands are called by Captain Wilson Rooapoa and Rooahooga, though it is stated in the narrative of his voyage, and confirmed also by Krusenstern, that the natives do not use the letter *r*.

The principal productions of these islands are, the cocoa-palm, the bread-fruit tree, the plantain tree, or rather bush; the casuarina, a heavy hard wood like mahogany, of which the natives form their clubs, lances, and mallets; a species of dwarf fir; a species of wild fig-tree, supposed to be employed by the natives in the construction of their canoes; a species of walnut tree, with a fruit of excellent flavour; and the paper mulberry-tree, from the bark of which the inhabitants make their cloths. There are found also yams, and a sort of sweet potatoe; a species of apple about the size of a medlar; cucumbers, resembling those which grow without culture in the West India Islands, and calabashes or pumpkins; water-cresses and purslain in great abundance, and of excellent quality. The sugar cane was observed, on Santa Christina, growing in the woods to the height of 6 or 7 feet; but the natives appeared to be unacquainted with its value.

With the exception of rats, (which in some of these islands have multiplied to a degree which is very detrimental to the inhabitants,) the only quadruped is the frog. These animals have been seen in great numbers by most navigators who have touched on the Marquesas; but the natives discover great reluctance to dispose of them. Poultry also are generally seen about the habitations, but appear to be neglected by the natives, and to be valued more for their feathers than their flesh. The woods are stocked with numbers of small birds; and among the aquatic fowl on the coast, were particularly noticed, man-of-war bird, tropic birds, boobies, herons, and sea-swallows. The adjoining sea furnishes the most excellent fish, among which the bonito was observed to be particularly abundant.

The natives of the Marquesas surpass all the other islanders of the Pacific Ocean in point of personal beauty; but are inferior in respect of cleanliness to the inhabitants of the Society and Friendly Isles. The men are invariably of a large stature, muscular, and well made. Many of them are about six feet in height; and the most handsome forms that nature ever produced are to be found among them. They have no animation in their eyes, but great regularity of features, and a most benevolent expression of countenance. Their colour is not much different from that of Europeans, except that it approaches nearer to yellow; but, by tattooing their bodies very much with a black colour, they acquire a dark appearance. The women are generally short of stature, and rather awkward in their gait, except in Santa Christina, where they are taller and finer figures; but they have well-proportioned heads, delicately formed hands and feet, countenances rather round than oval, blooming complexion, large sparkling eyes, fine teeth, and curled hair, neatly ornamented with a white fillet. They are destitute, however, of the gentle expression, which is described as so common in the features of the Otaheitan females; and are rather remarkable for a disgusting cast of lewdness in their looks. As soon as the men attain the age of puberty, their whole bodies, and even faces, are tattooed in a singularly regular and tasteful manner; but the lower classes are less completely marked, and many of them not at all; so that this kind of ornament appears to denote some distinction of rank or character. The women have only their hands, arms, lips, and lobes of the ears adorned in this manner.

The men go always naked, except a small girdle of the bark of the cloth-mulberry around their loins. Mats are sometimes used among them; but are generally fastened under the chin in such a manner as merely to cover the back. They are, however, very fond of ornaments; and most of them wear head-dresses, consisting of a large helmet of black cocks' feathers, or a band of woven cocoa fibres, ornamented with mother-of-pearl, or a ring of soft wood, from which a row of strings is suspended, or merely broad leaves stuck in the hair. They adorn their ears with large white muscles of a circular form, and with perforated boars' teeth; but their chief attention is bestowed upon the ornaments for the neck, which consist of gorgets of soft wood, shaped like a crescent, to which rows of red beans are affixed; or a band of cocoa fibres hung with boars' teeth, or balls of the size of an apple studded with red beans. All that they receive or steal from strangers is hung openly about the neck or waist; and on various parts of their bodies are hung, or tied, tresses and knots of hair, which they seemed to hold in great estimation. Some were observed, also, with sculls suspended from their necks. They usually shave their beards, with the exception of a single tuft on the chin, from which a boars' tooth is frequently suspended; and sometimes pluck the hair from the point of the chin, leaving a tuft on each side. The dress of the women consists of a girdle like that of the men, drawn between their thighs; or a large piece of cloth wrapped several times round their waist, with the ends tucked up like the girdle; and above this a large shawl, or sheet, tied at the upper corners with the knot laid over one shoulder, and the rest of the garment hanging loose half way down the leg. They did not appear to wear so many ornaments as the men; but always carry fans neatly platted with grass, and coloured white with burnt muscle shells. They daily anoint their hair, and the whole of their bodies, with cocoa-nut oil, which produces a high gloss, but a disagreeable smell; and besides serving the purpose of an ornament, appears intended to protect them from the rays of the sun, and the attacks of insects.

Their food consists chiefly of roasted bread-fruit, fish, akee-nuts, a paste made of a kind of yam, and a sour pudding, called *mahie*, prepared from the bread-fruit and taro-root, and resembling an apple-tart. To these may be added hogs, when they can be procured, and which they eat with great relish. They have no regular meals, but eat when they are hungry, and generally in a very voracious manner, snatching up the mahie with their fingers, and carrying it greedily to their mouths. They bake their food upon banana leaves, which also supply the place of dishes, and use, in all respects, the most simple kind of cookery—sometimes, indeed, eating both fish and pork in a raw state. They rarely drink the kava juice, and never to any excess; but their common beverage is water, even, at times, sea-water. The women are not wholly prohibited, as in most of the other South Sea islands, from eating with the men, and tasting the flesh of the hog; but appear to be very sparingly indulged in either of these privileges. At Santa Christina, it is considered as an act of civility to offer to a friend the food which they have chewed, that he may have no farther trouble than that of swallowing it.

Their houses are generally long and narrow, are constructed of bamboo, interwoven with the leaves of the cocoa-tree and fern, and covered with dried leaves of the bread-fruit tree, the roof sloping from the back-wall, which is higher than the front. The inside of the dwelling is divided into two parts, by a beam laid along the ground from one end to the other, the foremost of which is paved with stones, and the innermost covered with mats, upon which the whole family sleep promiscuously. At one end is a small partition, within which the most valuable effects are deposited; and along the walls and roofs are suspended calabashes, drums, arms, &c. The door, about three feet high, is in the centre of the building, and the family usually sit around the entrance. Some of the wealthier individuals have another building about 20 fathoms distance from the ordinary residence, nearly of the same dimensions, but a few feet higher, and provided with a platform or pavement, about ten or twelve feet wide, running along the front, and serving the purpose of a banqueting-hall. In Santa Christina the houses are raised above the ground on stone platforms, which is supposed to imply that the island is occasionally subject to inundations—a conjecture which is confirmed by the circumstance of stilts being seen very commonly about the habitations, and of the natives frequently practising the exercise of walking upon them. At a short distance from the houses are several holes paved with stones, and covered with branches, which serve as store-houses for the provisions. Their household utensils consist of cocoa-nut shells and calabashes, both of which are frequently ornamented with the finger or arm-bones of their enemies; large covered dishes of a thin brown wood, formed in the shape of muscles, and adorned with carved figures; fishing-lines, nets, ropes, and mats, made of cocoa-fibres, or the bark of a species of nettle; fishing-hooks, resembling tenters, rather clumsily made of mother-of-pearl, and razors made of sharks' teeth.

Their tools are extremely simple, consisting of a pointed stone or bone to bore holes; pieces of shell, sharp-edged, or toothed like a saw; a hatchet of black hard stone, in the form of an elongated wedge; and bits of iron, procured from Europeans, fastened to handles of wood.

Their weapons consist of clubs about five feet long, and so massy as to weigh about ten pounds, beautifully polished and carved; spears about ten feet in length, one inch thick in the middle, and pointed at each end; a sort of sabre, shaped like the blade of an oar; and slings, made of a woven band, broad and flat in the middle, to admit the stone.

The canoes of the Marquesans are inferior to those of Otaheite, both in strength and neatness. They are from 20 to 30 feet in length, and from 12 to 18 inches broad, composed of three pieces rudely wrought, and badly sewed together with threads of the cocoa-nut fibre. Sometimes two of them are joined together, but more frequently they are furnished with an outrigger of bamboo to keep them steady.

These people have little employment, and few manufactures. The culture of the soil requires little of their attention, and consists only in digging a hole, and putting into it a branch of the bread-fruit, cocoa, or banana plants, which, in a month's time, are in full growth without any farther care. They are also very indolent in fishing, and only the poorer classes apply to the ocean for subsistence. The only work of any consequence, in which the men engage, is the construction of their houses, canoes, and weapons, which, however, occupies them but seldom; and they spend their lives, in a great measure, in complete idleness. The women seem to have more employment, in making twine for various purposes, fans for themselves and husbands, and particularly cloth of the mulberry bark. The finer kind is of a brilliant white colour, and the coarser, of a greyish hue, generally died yellow; but none of their pieces equal the cloth of the Society Isles either in beauty or strength. They weave mats very neatly with the leaves of the palm-tree.

Their amusements are dancing, singing, and, above all, swimming. Their dancing consists in hopping on the same spot in a very unanimated and unvaried manner, moving their fingers with great velocity, and beating time with their hands on different parts of the body. Their singing is nothing but a discordant howl; and their musical instruments, which consist of large drums, conchs, and bamboo pipes, produce no kind of harmony, but hollow monotonous sounds. They never seem to tire of swimming, but spend whole days in the water.

Their most serious occupation consists in the practice of hostilities, which are frequently carried on between the inhabitants of the different islands, or even of the different valleys in the same island. These wars are conducted more after the manner of beasts of prey than of human beings, as the combatants rarely meet in the open field, and in large parties, but practise all kinds of ambuscade to surprise their adversaries, whom they butcher and devour on the spot. These wars are generally terminated by one of the contending chiefs demanding a truce to celebrate the dance feast, for which a year's preparation is often required, and in which, as at the ancient Olympic games, all parties assist. But should one of the high-priests happen to die, (at whose interment three human victims from a hostile tribe must be sacrificed,) instantly an expedition is dispatched to procure the requisite victims, and a general war is frequently the consequence.

No regular government, and scarcely the form of any official authority, has been observed among these islanders. Those individuals who seemed to be acknowledged as chiefs, were distinguished by nothing in their dress or appearance from the lowest of the people, and no respect was paid to their orders. The only influence which any one among them appeared to possess was considered as arising from his superiority in courage, strength, wealth, or the number of his family and dependants. No provision is made for the administration of justice; nor is any thing almost counted a crime, except murder; and, even in this case, punishment is not inflicted by the chiefs or priests, but vengeance is exacted by the friends of the deceased.

There have been as few traces of religion as of government hitherto observed among these islanders, excepting in Martin's island, where, at least, a class of priests exist, who exert some species of influence upon the minds of their countrymen. They exhibit some confused notion of a divine being, whom they call Etooa; but they give the same name to the spirit of a priest, of a king, of any of his relations, and generally to all Europeans, as superior beings. The principal appearance of a religious feeling is found in their reverence for any thing pronounced to be "taboo," or sacred, which a priest only can extend to any general object, but which every person may effect upon his own property by merely declaring that the spirit of his father, or of some king, or of any other person, reposes in the spot or article which he wishes to preserve. They have a universal belief in charms, (which they name "kaha,") which kill, by imperceptible means, and slow degrees, those against whom they are directed, and which the priests chiefly are understood to be able to render effectual. The person who wishes to avenge himself in this way endeavours to procure the saliva, urine, or excrements of his victim, which he mixes with a certain powder, and encloses in a bag woven in a particular manner. The secret of the matter consists in the preparation of the powder, and working of the bag. This bag, with its contents, being secretly buried, the object of the charm becomes sick, and gradually decays in strength, till he expires on the 20th day; but may, at any time before that period, recover his vigour by a propitiatory present to his enemy. Some reference to a future life appears in their funeral rites. The corpse is washed and laid upon a platform under a piece of new cloth; and, to obtain a safe passage for the deceased through the lower regions, a great feast is given by the family to the priests and the relations. The body continues to be rubbed for several months with cocoa-nut oil, till it becomes quite hard and incorruptible; and a second feast, exactly twelve months after the first, is then given, to thank the gods for having granted to the deceased a safe arrival in the other world. The corpse is then broken in pieces, packed in a box, and deposited in the morai or burying place, which no woman is permitted to approach upon the pain of death.

The language of the Marquesas resembles so nearly that of the Society Isles, that the natives of both understand each other. They make no use of the letters *r*, *z*, *s*, or *x*, but have a number of strong aspirates in their words, and speak with considerable vehemence. The population in these islands, owing to frequent wars and licentious manners, is much inferior to what the fertility of the soil and mildness of the climate might encourage us to expect; and, according to the most probable calculation, the larger islands do not contain above 6000 each.

These islanders have appeared to all the navigators who have visited them for a few days to be a remarkably peaceable, hospitable, and humane people; honest in traffic, and friendly in every form; variable and fickle in their pursuits; but constantly cheerful, good-humoured, and devoted to the pleasures within their reach. But a longer residence, and closer acquaintance with them, have proved them to be not less savage than licentious in their character, and to unite the most ferocious appetites of the brute with the most attractive features of the human form. Besides their shameless laxity of morals, exhibited to every European view, they live among themselves, with something, indeed, like the form of marriage, but in the actual practice of almost universal concubinage; and gratify their sensual passions in open day with less reserve than most of the lower animals. Like the greater part of the South Sea islanders, they devour the bodies, and suck the blood of their enemies in times of war; but the Marquesans go a degree farther than any of their neighbours have yet been known to do; and, in times of famine, butcher their own wives and children, and aged parents, and having baked and stewed the flesh of these hapless relatives, feast upon the horrid food with the greatest satisfaction. Fear alone prevents them from murdering and devouring every stranger who touches on their shores. See Cook's *Second Voyage*, vol. i.; Wilson's *Missionary Voyage*; Marchand's *Voyage*, vol. i.; and particularly Krusenstern's and Lisanstey's *Voyages round the World*. (*q*)

MARRIAGE. See Adultery, Divorce, and Law.

MARS. See Astronomy.

MARSEILLES, formerly *Massilia*, the most ancient city of France, and founded by a Greek colony, is the capital of the department of the Bouches du Rhone, and is situated near the Mediterranean, at the foot of a rocky mountain, and is divided into the Old and New Town. The Old Town, situated on a long hill to the east of the harbour, is traversed with three great streets, crossed by others of a smaller size. They are all narrow and crooked. The houses are mean, and inhabited chiefly by fishermen and the poorer classes. The New Town has wide and straight streets, the finest of which are called Beauvau and La Canebiere, with good pavements for foot-passengers; and the houses are regularly built, elegant, and commodious. The finest squares in Marseilles are, the Place Castelane, the Place St. Ferreol, the Place de la Comedie, and the Place de Moutiers. The principal public buildings and curiosities, are the Town-house, or the Exchange, on the lodge of which are the royal arms, executed in a very fine style by Puget; the Cathedral Church, which is the most ancient in France; the Arsenal, which was once reckoned the finest in the kingdom, and contained arms for 40,000 men, and a dock for building the galleys; the Theatre, which has an annual revenue of 300,000 livres, the hall of which is much admired; the church of St. Victor, containing very ancient busts and inscriptions; the column raised in 1802, in memory of the physicians who hazarded or lost their lives during the plague of 1720; the fountain with the column raised to Homer by the descendants of the Phocians; the Consigné, which contains Puget's famous bas-relief of the plague; the tombs of Homer and Puget, containg his bust, and several sculptors; the Cidevant Chatreuse, about half a league from the town; the Lazaretto, reckoned one of the finest in Europe; the strong castle of If, a fortress and state-prison, upon a small islet, from which there is a fine view of the harbour and the town, and which is supposed to have replaced the ancient temple of Diana. There are three hospitals at Marseilles, viz. the Hotel de Dieu, a very fine building, which holds 600 patients; the Hospital of the Poor, a vast and regular edifice, which accommodates 800 patients; and the Lunatic Hospital.

The Museum of Lyons is now contained in the ancient convent of the Bernardines. The principal body of the building, with its fine courts and gardens, is devoted to the Lyceum, and the rest is used for the museum, the school of design, the public library, and the meetings of the academy, and the other public societies. During the revolution, the articles of the Museum were either dispersed, or heaped up in the court of the Lyceum; but M. Thibadeau had the merit of bringing them together; and a catalogue of them was published in 1805 by M. Fauris-Saint-Vincens. The Museum contains various Greek, Roman, and Christian monuments. The principal Greek antiquities are, a sun dial; a round, and a triangular altar; a tomb representing the last adieus of a warrior; the tomb of one Telesophorus and his wife; and the tomb of Glaucias, with an inscription. The Roman monuments consist of several sarcophagi, with inscriptions; a marble chair; a tragic masque; and an

Isis of basalt. The Christian monuments are more numerous, but less interesting.

The harbour of Marseilles, and the quay by which it is flanked, have been long and justly admired. The principal quays are those of St. John and St. Nicholas, the first of which is defended by the fort of St. John. The length of the harbour is 500 fathoms, and its width 160. Before the revolution 4500 vessels entered it every year, and brought to it the productions of all the quarters of the globe. In 1788, 5000 vessels entered the harbour, and in 1805 scarcely 1000.

The best view of the town and harbour is from the top of the Fort of Notre Dame de la Garde, and from the platform of the Observatory, a building which was erected between 1699 and 1702, which has acquired some celebrity from the numerous comets which have been discovered there by that assiduous astronomer M. Pons. The environs of Marseilles are covered with about 5000 small pleasant houses, called des Bastides. The ramparts of the town have been replaced by magnificent boulevards.

The principal manufactures of this city are, marble, soap, porcelain, earthen-ware, hats, perfumes, painted cloths, and tapestry. It has several refineries of sugar, sulphur, alum, glue, and sumac, and also a celebrated manufactory of coral.

The literary and scientific establishments of this town are, an Atheneum; a Society of Medicine; an Academy of Science, established in 1726; the Society of the Interior of Africa; the Museum; the Garden of Naturalization; a Cabinet of Natural History, founded in 1803; and the Marine Observatory. Population 96,413. East Long. of Observatory 5° 22′ 15″. North Lat. 43° 17′ 49″. See Millin's *Voyage*, tom. iii. p. 135.

MARTIAL, Marcus Valerius, an eminent Latin poet, was born at Bilbilis, (now called Bubiera,) a town of Arragon, in Spain. He was educated in his native country, and was sent to Rome, at the age of 21, to prosecute the study of the law. Having devoted himself, however, to poetry, his talents ingratiated him with the principal literary characters in Rome, and procured him imperial patronage. For the latter, he was indebted perhaps more to his gross adulation than to the merit of his verses. He was rewarded by Domitian with the rank of a Roman knight, and the privileges of a father of three children. After remaining 34 years at Rome, finding himself neglected by the Emperor Trajan, he returned to his native country, where he married a lady who appears to have brought him some fortune, and with whom he lived happily for several years. The date of his death has not been precisely ascertained.

Martial is the most celebrated of the Roman epigrammists. There are still extant fourteen books of his epigrams. His style is affected; and he is often detestably obscene. Many of his epigrams, however, are excellent; and he has given some beautiful specimens of elegant latinity. His frequent allusions to Roman habits and customs render his works a very instructive study to the classical antiquary.

There are numerous editions of Martial's works. The best are the *Delphin* and *Variorum* editions. See Vossii *Poet. Lat.*; Crusius's *Lat. Poets.*; Tiraboschi; and Aikin's *Gen. Biog.*

MARTIGNY, or Martinach, a small town of Switzerland, in the Lower Valais, is situated in the valley of the Dranse, near its confluence with the Rhone. The town is situated 336 feet above the lake of Geneva, and 1734 feet above the sea. The church is old and has a prettly lofty spire; but the greatest ornament of the place is the magnificent castle of La Bathia, situated on the extremity of a lofty calcareous rock, the bottom of which is washed by the Dranse. There are many beautiful fields and orchards round the town. Martigny is the *Octodurum* of the Romans.

MARTINIQUE, called *Madanina* by the natives, is one of the largest of the Caribbee islands in the West Indies. It extends about 50 miles from north-west to south-east, and is 16 broad, and 140 in circumference. It is divided into 28 parishes, and contains about as many towns and villages. The interior of the island is covered with conical hills; but, with the exception of three mountains of considerable height, the hills are very small. The highest mountain, called Pelée, appears to be an extinct volcano, and the other two are in a great measure cultivated. The principal stream which flows from these mountains, is called Galion, and waters the north-east part of the island. There are about forty rivulets, several of which are navigable for two or three leagues, and ten are never dry.

The principal productions of the island are, sugar, cotton, indigo, cocoa, and ginger; and, from the number and security of its bays and harbours, it is well adapted for trade. In the year 1769 the principal articles which the island produced were,

Sugar - - -	189,195	quintals.
Coffee - - -	68,518	
Cocoa - - -	11,731	
Cotton - - -	6,048	
Cassia - - -	2.518	
Rum - - -	783	hhds.
Molasses - -	307	

These articles of export, in addition to the quantities of indigo, sweetmeats, chocolate, snuff, rope yarn, liqueurs, dyeing wood, and hides, employed 202 vessels.

The productions of the island were, a few years ago, computed at

Sugar - - -	23,000,000	lbs.
Coffee - - -	3,000,000	
Cocoa - - -	40,000	

The exports and imports in 1769, 1788 and 1810, were as follows:

	Imports.	Exports.
1669,	*L*588,412	*L*436,631
1788,	1,195,111	1,201,875
1810,	635,664	791,773

A part of the imports were always sent to the Spanish Main.

No mines have yet been discovered in Martinique. A ferruginous sand was found on the shore near Mount Pelée. Quarries of freestone are rare, and blocks of lava are used.

The principal towns of Martinique are, Port Royal, the capital, and St. Pierre. Port Royal is situated on the west coast, in a large bay, which forms one of the best harbours in the West Indies. The citadel cost no less than 325,000*l.* sterling. St. Pierre, situated on the west coast, to the north of Port Royal, is built on the the side of a hill, and has a beautiful appearance with its fine white buildings. It is a port of entry, and the most convenient town in the island. The bay, which is circular, has an easy access, but is not safe in storms. The population of St. Pierre is about 20,000. The other towns are Cul de sac Robert, Trinity Fort, and Cul de sac Francais. The following is a tabular view of the population of the island at different periods:

1700	6597	whites.	21,660
	507	free blacks and slaves.	
	14 566	slaves.	
1770	11,588	whites.	85,254
	2.524	free blacks.	
	71,142	slaves.	
1776	11,619	whites.	85,779
	2,892	free blacks.	
	71,268	slaves.	
1788	10 603	whites.	88,870
	4,851	free blacks.	
	73,416	slaves.	

This island was settled, in 1635, by 100 French emigrants from St. Christopher's, under M. Desnambuc, who succeeded in extirpating the Caribs. In 1650, they began the culture of sugar; and in 1660 cocoa trees were planted. In 1718, when the cocoa trees were destroyed, the coffee tree was introduced. In 1763 it surrendered to the English, and was soon after infested with vast swarms of ants, which destroyed every vegetable in the island. In the year 1794, Martinique was taken by the British under Sir John Jervis and Sir Charles Grey. It was restored to the French at the treaty of Amiens in 1802, and was again taken by the British under general Prevost, on the 24th February 1809. It again reverted to the French at the general peace in 1815. West Long. of the Port de France 61° 5′ 45″, North Lat. 14° 35′ 49″.

MARSH'S SYSTEM OF MUSICAL TEMPERAMENT. A work was published in 1810, entitled a *Theory of Harmonics*, by J. Marsh, who is understood also to have been the author of a previous critique on the late Lord Stanhope's musical pamphlet, inserted in the *Monthly Magazine*, vol. xxii. p. 349. In both of these writings, Mr. Marsh proposed a principle of temperament, in which a certain ratio should be given, between the equally sharp temperaments of the two lower of three consecutive major thirds above C, and the temperament of the upper or wolf-third of those which is to complete an exact octave. In the earliest of these writings, in 1806, Mr. Marsh recommended the said temperament and the wolf to have the ratio 1 to 2; but in page 13 of his *Harmonics*, he proposed the ratio of these to be 1¼ to 3½, or 5 to 14; as Mr. Farey has remarked, in a note in p. 48 of vol. xxxvi. of the *Phil. Mag.*

In the page last quoted, Mr. Farey has calculated, that Mr. Marsh's ratio of 5 : 14, gives a sharp temperament of 4.378276Σ, to the IIIrds; a flat temperament of 1.657397Σ to the fifths; and a sharp temperament of 6.035671Σ to the VIths, in a regular douzeave; for whose twelve notes Mr. Farey calculated the *vibrations*, as they are inserted in the third column of the following table; the six last columns of which were calculated by the Rev. C. J. Smyth, one of the minor canons of Norwich cathedral, as is mentioned in p. 437 of vol. xxxvi. of the *Phil. Mag.* already quoted.

1	2	3	4	5	6	7	8	9
C	612 12 53	480.0000						
B	558 12 48	451.3838	18.3838	31.4802	2.3802	2.5306	17.7984	15.4250
♭B	511 11 44	428.2657	40.0412	10.6067	3.2066	2.4007	47.0736	14.7447
A	457 8 40	402.7338	16.4028	9.9734	3.0162	2.2478	15 8794	13.7622
♯G	403 8 35	378.7240	15.4250	26.3800	2.8753	♯ 8.0876	14.9330	29.9746
G	356 7 31	359.3272	14.7447	8 8992	2.6912	2.0140	14.1686	12.2794
♯F	302 6 26	337.9052	13.7622	23.5368	2.5306	1.8944	13.3226	26.7434
F	256 6 22	320.5991	29.9746	7.9397	2.4007	1.7973	35.2398	10.9559
E	201 5 17	301.4859	12.2794	7.4665	2.2478	1.6901	11.8872	10.3023
♭E	155 4 13	286.0449	26.7434	7.0843	♭ 8.0076	1.6033	31.4802	9.7755
D	101 1 9	268.9919	10.9559	6.6613	2.0140	1.5081	10.6067	9.1919
♯C	46 1 9	252.9553	10.3023	17.6199	1 8944	1.4379	9.9734	20.0206
C	0 0 0	240.0000	9.7755	5 9436	1.7973	1.3456	26.3800	8.2014
Notes.	Σ f m Approximate Listonian notes.	Vibrations in 1″ of time.	Flat, 3rds.	Sharp, IIIds.	Sharp, 4ths.	Flat, Vths.	Flat, 6ths.	Sharp, VIths.
			Beats in 1″ of time.					
		Sums.	218 7908	163.5916	35.0624	28.4774	248.7429	181.3769
		Isotonicsums, vol ix. p. 274	217.8068	160.1699	18.2413	13 6659	254.2546	183 1527

In the first column are placed the 12 common notes; in the second, the new notation of these notes in Liston's scale, (as extended by Farey,) nearest to those whose vibrations are expressed in column third, and the beats in the six following columns, where it must be noted, that the 4th on ♭E, and the Vth on ♯G, beat differently from what the general title states. Below the title are placed the sums of the numbers of beats of each of the six concords; and below this, for comparison, is placed the corresponding sums of the isotonic beats. The total of Mr. Marsh's beats thus appear to be 876.0420, and of the isotonic 847.2912.

MARY, QUEEN OF SCOTS. See SCOTLAND.

MARYLAND, one of the United States of America, is bounded on the north by Pennsylvania and Delaware, on the east by Delaware and the Atlantic, and on the west and south-west by Virginia.

This state extends along each side of the Chesapeake Bay to its northern boundary, which is 196 miles long. On the broadest part, on the east of the bay, it is 120 miles wide. On the north-west, a little above Hancock town, it is only three miles wide; at Cumberland six; and at the western boundary forty. It contains about 10,800 square miles, or 6,912,000 acres, of which about one-fifth is water. It is divided into 19 counties, 11 of which are on the western, and 8 on the eastern side of the Chesapeake, as follows:

		Population in 1810.	*Chief Towns.*
West of the Chesapeake.	Harford	21,258	Bellair.
	Baltimore	75,810	Baltimore.
	Anne-Arundle	26,668	Annapolis.
	Frederick	34,437	Frederick Town.
	Alleghany	6,909	Cumberland.
	Washington	18,730	Elizabeth Town.
	Montgomery	17,980	Verity.
	Prince George	20,589	Marlborough.
	Calvert	8,005	St. Leonard.
	Charles	20,245	Port Tobacco.
	St. Mary's	12,795	Leonard's Town
	Total Western	263,425	

		Population in 1810.	*Chief Towns.*
East of the Chesapeake.	Cecil	13,066	Elkton.
	Kent	11,450	Chester.
	Queen Anne	16,648	Centreville.
	Caroline	9,453	Denton.
	Talbot	14,230	Easton.
	Somerset	17,195	Princess Ann.
	Dorchester	18,108	Cambridge.
	Worcester	16,971	Snowhill.
	Total Eastern	117,121	

Total Population 380,546, of which 235,117 are whites, 111,502 slaves, and 33,927 free blacks.

In the eastern counties the land is generally low; with tracts of marshy soil. The western counties, up to the lowest falls of the rivers, are finely variegated, but from these falls to the Blue Ridge the country is uneven and mountainous, being crossed by the ridges of the Aleghany mountains. Frederick and Washington are the most fertile counties. There are several fine valleys between the western mountains. The good land produces from 12 to 16 bushels of wheat, or from 20 to 30 of Indian corn per acre. The staple productions of this state are wheat, Indian corn, and tobacco. The genuine white wheat is said to be peculiar to the county, and also the bright kites-foot tobacco. In 1816, the growth of tobacco was estimated at 19,000 hogsheads; 1000 lbs. of tobacco being the produce of 6000 plants.

Maryland possesses a great number of manufactures, the amount and value of which are seen in the following Table for 1810.

	Value in Dollars.
Two iron works in Frederick County	
Two glass works, making 540,000 square plate, and 70,000 bottles	72,660
Gunpowder, 323,447 pounds	164,122
Salt, 7538 bushels	3,769
Marble	10,000
Millstones, 1 manufactory	6,000
Soapstone	1,000
Potters' ware	360
Tobacco, 5100 hogsheads	204,000
Flaxseed oil, 16,375 gallons	14,950
Spirits, 733,042 gallons from mint and grain, 127,700 from molasses	509,660
Beer, 7 breweries, 9330 barrels	69,380
Starch and hairpowder, 157,314 pounds	27,000
Paper, 22,200 reams	77,517
Refined sugar, 755,879 pounds	150,000
Snuff	200,000
Roll, 1080 tons	561,800
Turmeric, 200 lbs.	40
Chocolate, 9000 lbs,	1,800
Wheat, 307 mills, 328,483 barrels	2,530,765
Tortoise-shell, ivory, and horn	28,000

In addition to these, there are 113 saw-mills, 80 grist-mills, 3 wind-mills, 2 paper-mills, and 400 stills for distilling whisky from rye.

The total amount of manufactures in 1810 were 11,468,794, besides other articles, amounting to 2,734,765, making a total of 14,203,559 dollars.

Maryland exports to the West Indies, England, France, and the north of Europe, wheat, flour, corn, tobacco, flax-seed, beans, pork, and timber. The wheat exported was, in

1815.—222,000 barrels to foreign places.
140,000 barrels to other parts of America
1816.—187,000 barrels to foreign places.
170,000 barrels to other parts of America.

The tobacco exported was, in

1815.—27,000 hogsheads.
1816.—12,000 hogsheads.

The imports of Maryland are dry goods, hardwares, wines, and spiritous liquors; rum, sugar, and coffee, from the West Indies.

In the year 1813, there were 14 banks in this state, the united capital of which was 11,450,000 dollars.

The principal towns in Maryland are Baltimore, Annapolis, Fredericktown, and Elkton. *Baltimore* has already been fully described in a separate article. In the year 1817, its population was 55,000. The number of vessels from foreign ports, which entered in that year, was 632, and the number of coasting vessels 758; 422 cleared out for foreign ports, and 896 for ports within the United States. The public library at Baltimore contains about 12,000 volumes, for the reception of which a handsome building is now (1819) erecting. In 1805, the exports from Baltimore amounted to 10,859,480 dollars, and the imports to nearly the same. In 1811, the registered tonnage of Baltimore was 88,398 tons. In 1817, there was a private insurance office and eight chartered marine insurance companies, whose nominal capital amounts to 4,000,000 dollars. In the same year, the chartered banks in Baltimore, nine in number, had a capital of 10,000,000 dollars.

Annapolis has already been described in a separate article.

Fredericktown is a fine flourishing inland town, consisting principally of one broad street, built of brick and stone. It has seven places of worship, besides public buildings. Its population is now 4500.

Elkton is situated near the head of Chesapeake bay, on a small river of the same name. It has great advantages for the carrying trade between Baltimore and Philadelphia.

The principal rivers of Maryland are the Patuxent, which, after a south-easterly course of 110 miles, empties itself into the Chesapeake, between Drum and Cedar points, and admits vessels of 250 tons to Nottingham, 46 miles, and boats to Queen Anne, 14 miles farther; the Patapsco, the Pocomoke, the Wicomico, the Nanticoke, the Choptank, the Chester, the Sassafras, and the Elk. The Potowmac, the Susquehannah, and the Youhiogany, also flow through, or bound the state.

About two-thirds of the Chesapeake bay are in Maryland. The bay is nearly 200 miles long, and from 7 to

30 broad, with nine fathoms of water. It has numerous branches, which are navigable 20 or 30 miles from the outlet.

Iron ore of a good quality is found in different parts of the state. Extensive beds of nodular iron ore occur about three miles west from Baltimore. Chromate of iron is found near the same place. Native copper occurs in the Blue Ridge in Washington county; arsenical grey copper at Pipe Creek and at Liberty, and lead ore near Baltimore. Marble is wrought near the Potowmac river in Montgomery county, and two beds of coal have lately been discovered near Baltimore. Limestone exists in great quantity, and forms a cavern in Washington county. Whetstone, fetid carbonate of lime, agate, jasper, and talc, are also found in the county.

The university of Maryland consists of Washington College, at Chestertown, in Kent, and of St. John's College at Annapolis. The first was founded in 1787. In 1811, 1000 dollars a-year were added to its revenues. St. John's College was instituted in 1784. In 1811, the number of students had diminished from 150 to 60. See Morse's *American Geography*, p. 209, and Warden's *Statistical, Political, and Historical Account of the United States of Northern America*, vol. ii. p. 137, Edin. 1819.

MARYPORT, a market town of England, in the county of Cumberland. It is pleasantly situated near the sea, on the river Elden, by which it is divided into two parts. The streets are wide, and the houses neatly built. On each side of the river, wooden piers and quays have been erected. About 100 vessels belong to the port, and are principally occupied in exporting coals to Ireland, and in importing timber, flax, and iron from the Baltic. About 400 persons derive employment from a cotton manufactory established here some time ago. On the eminence called Mole Hill is an artificial mount, whose base is 160 yards in circuit, and is nearly surrounded by a deep ditch. The number of houses in 1801 was about 250, and the population nearly 3000. See the *Beauties of England and Wales*, vol. ii. p. 206.

MASKELYNE, Nevil, D. D. a celebrated English astronomer, who held the office of astronomer royal for nearly half a century. He was born in London on the 6th of October, 1732. At the age of nine he went to Westminster school, where he made great progress in his classical studies, and at the same time exhibited a taste for optics and astronomy. It is a curious circumstance, that the solar eclipse of 1748 decided the attachment both of Maskelyne and Lalande for the study of astronomy.

In 1749, Mr. Maskelyne went to Cambridge, and entered first into Catherine's Hall, and afterwards into Trinity College. In 1754, he took his degree of B. A.; in 1757, that of A. M.; in 1764, that of B. D.; and in 1777, that of D. D. In 1755, he accepted of the curacy of Barnet, where he resided several years, and devoted his leisure hours to the study of astronomy. About this time he appears to have made different calculations for Dr. Bradley, the astronomer royal. In 1758, he was chosen a fellow of Trinity College, Cambridge; and, in 1759, he was made a fellow of the Royal Society.

In 1761, Dr. Maskelyne was selected by the Royal Society to go to St. Helena to observe the transit of Venus over the sun's disc. He accordingly sailed in the Seahorse frigate, and remained ten months on the island, where he made accurate observations on the tides, on the force of gravity, on the annual parallax of Sirius, and on the horary parallaxes of the moon.

After his return from St. Helena, Dr. Maskelyne published *The British Mariners' Guide*, in which he particularly explained the method of determining the longitude at sea from lunar observation. In 1763, he performed a voyage to Barbadoes, on board the Princess Louisa, to determine the rate of going of Harrison's new timekeeper; to try Mr. Irwin's marine chair, and to make other astronomical observations.

Upon the death of Dr. Bliss, in 1764, Dr. Maskelyne was appointed astronomer royal; a situation which he filled for 46 years, with the greatest honour to himself, and the highest advantage to his country. As a member of the Board of Longitude, he submitted to them the plan of a nautical almanac, which was consequently begun in 1767, and has been regularly continued since that time, to the great advantage of navigation. In 1767, he published a work, entitled, *Tables requisite to be used with the Nautical Almanac, in order to find the Latitude and Longitude at Sea*, which has passed through numerous editions. In 1770, he published Tobias Mayer's *Tabulæ Motuum Solis et Lunæ*, to which he annexed a preface, with tracts and tables of his own.

In the year 1774, he went to Schehallien in Perthshire, (see our article Attraction *of Mountains*, to measure its lateral attraction, with the view of ascertaining the mean density of the earth; and the paper in which he gave an account of these observations was rewarded by the Royal Society with the Copley medal.

The first volume of Dr. Maskelyne's observations, beginning with those of 1765, were published in the year 1774, at the command of his Majesty; and other three volumes have since been published at different times. He was the author of *twenty-eight* Memoirs, principally on astronomy, which have been published in the *Philosophical Transactions* from 1760 to 1794.

Dr. Maskelyne received good church preferment from his college; and as he was the last male heir of his paternal estates, his income was considerable. He married, when rather advanced in life, the sister and co-heiress of Lady Booth, in Northamptonshire, by whom he had one daughter. After an illness of some months, Dr. Maskelyne died, on the 9th February, in the 79th year of his age, and was succeeded as astronomer royal by John Pond, Esq. whose numerous and valuable observations with the splendid instruments constructed for the Royal Observatory by Mr. Troughton, have done honour to himself and his country, and contributed greatly to the promotion of astronomical science.

Dr. Maskelyne possessed the most amiable and gentle dispositions, and patronized with the most friendly zeal every person who took an interest in his favourite science. His moral were equal to his intellectual qualities; his piety was sincere and unaffected; and his name will be added to the list of great and good men, who have honoured their genius by their virtues, and added the testimony of their high talents to the truth of the Christian faith.

The reader will find a full account of Dr. Maskelyne's labours in our articles Astronomy, Attraction, Micrometer, and Observatory. A very interesting Eloge of him, written by that eminent astronomer, the Chevalier Delambre, is published in the Memoirs of the French Institute.

MASON, William, a late eminent English poet, was born in the year 1725. His father was a clergyman, and held the living of Hull. He took his first degree at St. John's college, Cambridge, from whence he removed to Pembroke college, of which he was elected a fellow, in 1747. In 1749, he became a master of arts, and entered into holy orders in 1754. He obtained the patronage of the Earl of Holdernesse, who presented him to the valuable rectory of Aston in Yorkshire, and procured for him the appointment of chaplain to his Majesty. In 1749, he printed an *Ode on the Installation of the Duke of Newcastle*, as chancellor of the university of Cambridge, which gained him some reputation. His *Monody to the Memory of Pope*, and *Isis, an Elegy*, added to his fame; which was still farther increased by his dramatic poems of *Elfrida*, published in 1752, and *Caractacus*, in 1759. In 1756 he published a small collection of *Odes*, in imitation of Gray; and, in 1763, a collection of *Elegies*. His poems, with the exception of the Installation Ode, and Isis, were collected and published in 1764, in one volume 8vo. and afterwards went through several editions. The first book of his *English Garden*, a didactic and descriptive poem, in blank verse, appeared in 1772; and the fourth and last in 1781. In 1775 he published the poems of his friend Mr. Gray, in one volume 4to. with memoirs of his life and writings.

Mr. Mason was warmly attached to the principles of liberty, and gave his zealous support to the friends of reform. During the American war, he addressed an *Ode to the Naval Officer's of Great Britain*, on the occasion of Admiral Keppel's acquittal, in which he strongly expressed his disapprobation of the hostile measures pursued against our transatlantic colonies. In 1782 he addressed an ode to Mr. Pitt, containing many manly and patriotic sentiments. In his youth, he had attempted a translation of Fresnoy's Latin poem on painting, which he now revised and published, in 1783, in a 4to volume, enriched with the annotations of Sir Joshua Reynolds, and other additions.

Besides the living to which he had been presented soon after taking orders, he obtained the preferments of precentor and canon-residentiary of the cathedral of York; where, in 1788, he preached an *Occasional Discourse* on the subject of the slave trade. In the same year he published an edition of the poems of his friend W. Whitehead, the poet-laureate, to which he prefixed a biographical memoir; and the centenary commemoration of the revolution, in that year called forth a new exertion of his lyric powers, in a *Secular Ode*, which breathed his usual spirit of freedom. He was both a lover of music and a proficient in that art; and, in 1795, he published *Essays, historical and critical, on English Church-Music*. An additional volume of his *Poems* was given to the public, in 1797. In this collection appeared his *Palinody to Liberty*, expressive of the change which had been wrought in his political principles by the melancholy events of the French Revolution.

Mr. Mason died in the month of April, 1797, at the age of 72, in consequence of a mortification occasioned by a hurt in his leg. His wife, a lady of amiable manners, had died of a consumption in 1767; and was buried at Bristol Cathedral. On her monument were inscribed some very tender and beautiful lines by her husband.

Mr. Mason was a man of exemplary character in private life, and distinguished by his worth and active benevolence. In his manners, however, there was a degree of formality, stateliness, and assumed superiority, which is not unusual among men of eminence, who have been accustomed to move in provincial circles. As a poet, he excelled more in lyric than in dramatic composition. He was an avowed imitator of Gray, in the gorgeous array of his diction, the dazzling splendour of his imagery, and the superfluity of his ornament; and he often exhibits a minute learning which borders upon pedantry, and displays more of the artificial mechanism of poetry than of its genuine spirit. In all his productions, however, he breathes the purest spirit of morality, and the warmest zeal for civil liberty.

A tablet has been placed to the memory of Mason in Poets' Corner, Westminster Abbey. Besides his avowed productions, the *Heroic Epistle to Sir William Chambers*, and some other pieces of political satire, have been ascribed to him; but whether he was really the author of these performances is still doubtful. See Aikin's *Gen. Biog.*

MASONRY, Free, is the name of an ancient and respectable Institution, containing individuals of all ranks and countries, and binding them to acts of mutual benevolence, by initiation into certain mysterious rites, and by the communication of signs and words, by means of which the members of the institution are capable of recognising each other.

The Chevalier Ramsay has endeavoured to prove that Free Masonry arose during the Crusades; that it was a secondary order of chivalry; and that its forms, originating in that warlike institution, were adapted to the peaceful habits of scientific men.* Bode represents it as the invention of English Jesuits.† Clinch deduces its origin from the institution of Pythagoras‡; and Barruel supposes it to be a continuation of the Knights Templars.

Without entertaining any extravagant opinion respecting the antiquity of the order, we think it must be universally admitted, that there is a striking resemblance between the institution of Free Masonry and the Eleusinian and Dionysian Mysteries, as well as the more recent institutions of the Essenes, the Kasideans, and the Pythagoreans.

The Dionysian artificers were an association that flourished some hundred years before Christ, and possessed the exclusive privilege of building temples and theatres in Asia Minor, and they erected the magnificent temple of Teos to Bacchus, the founder of their order. They were incorporated at Teos by the kings of Pergamus, and were actually subdivided into different lodges.‖

The earliest appearance of Free Masonry in modern times was under the form of a travelling association of Italian, Greek, French, German, and Flemish artists, who were denominated Free Masons, and went about erecting churches and cathedrals. The members lived in a camp of huts. They were under a surveyor, who directed the establishment, and every tenth man was called a warden, and overlooked those under his charge*.

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* Leyden's Preliminary Dissertation to the Complaynt of Scotland, p. 67, 71.

† MS. in the possession of Mounier.

‡ Anthologia Hibernica, for January, March, April, and June 1794.

‖ See Chandler's *Travels in Asia Minor*, p. 100. Chishull's *Antiquitates Asiaticæ*, p. 107, 138. Ionian Antiquities, p. 4, and Robison's Proofs of a Conspiracy, p. 20.

By means of this travelling association, the mysteries of masonry seem to have been introduced into Kilwinning in Scotland, and York in England, at a very early period.

In the year 1425, in the reign of Henry VI. the English Parliament, instigated by the Bishop of Winchester, passed an act, prohibiting the free masons from holding their meetings; but it would appear that it was not carried into execution; for, in 1429, a lodge was held at Canterbury, under the patronage of the Archbishop†. Henry VI. himself became a keen mason, and drew up a paper in his own handwriting, containing questions and answers respecting the nature and tendency of free masonry. This manuscript was procured from the Bodleian library by Mr. Locke, who transmitted it to the Earl of Pembroke, with several explanatory notes‡.

Free masonry was also patronised in Scotland by King James I. who empowered every grand master to receive annually 4*l*. Scots from every master mason, and also a fee at the initiation of every new member. In the reign of James II. the office of grand master was granted by the Crown to William St. Clair, Earl of Orkney and Caithness, and founder of the much admired chapel of Roslin; and, from his attention to the interests of the order, the office was made hereditary in his family. The Barons of Roslin held their principal annual meetings at Kilwinning, and regular lodges were formed in different parts of the kingdom, by charters of erection granted by the Kilwinning lodge.

When James VI. ascended the English throne, he neglected his right of nominating the office-bearers of the fraternity; and, in consequence of this, the Scottish masons granted two charters to the St. Clairs of Roslin, which exist in Hay's MS. in the Advocates' Library.

In 1736, William St. Clair of Roslin, having no children, resigned into the hands of the Scottish lodges the right of nominating their own grand master, and other office-bearers; an event which led to the formation of the grand lodge of Scotland.

The grand lodge of England was instituted in 1717, at a time when there were only four lodges in the kingdom; and, in 1730, was established the grand lodge of Ireland. In 1729, free masonry was introduced into the East Indies, and lodges were gradually formed in almost every part of the world. In 1735, the free masons were persecuted by the States General in Holland. In 1738, a formidable bull was issued against them in Italy by Pope Eugenius, which was followed by an edict equally severe, dated 14th January, 1739. In 1745, the Council of Berne prohibited the societies of free masons, under the severest penalties.

In 1743, free masonry was imported into Denmark from Scotland. In 1754, it was introduced from the same source into Sweden. In 1767, a lodge, with an English constitution, was established in Berlin; and the principles of the order were gradually diffused through every part of Europe.

Our limits will not allow us to enter into any farther details on a subject like this. The reader, however, will find very copious information respecting this institution, in a *History of Free Masonry*, published at Edinburgh in 1804. See also ILLUMINATI.

MASSACHUSETTS PROPER, the name of one of the United States of North America, situated between 69° 50′ and 73° 10′ of West Longitude, and between 41° 13′ and 42° 52′ of North Latitude. It is 130 miles long on its northern line, where it is bounded by Vermont and New Hampshire; 190 miles on its southern boundary, where it is separated from Connecticut and Rhode Island. On the west it is bounded by New York, and on the east by the Atlantic. Its average breadth is about 50 miles; its maximum breadth 100; and near Cape Cod it is only 15 miles broad. Its area is 6250 square miles.

This state is divided into 14 counties, and 290 townships, as follows:

	Townships.	*Population in* 1810.	*Chief Towns.*	*Population*
Berkshire	32	35,907	Stockbridge Lenox	1,260 -
Hampshire Franklin Hampden	64	76,275	Northampton Greenfield Springfield	2,631 - 2,767
Worcester	51	64,910	Worcester	2,577
Middlesex	44	52,789	Concord	1,633
Essex	23	71,888	Salem Newburyport	12,612 1,634
Suffolk	2	34,381	Boston	33,250
Norfolk	22	31,245	Dedham	12,172
Plymouth	18	35,169	Plymouth	4,228
Bristol	16	37,168	Taunton	
Barnstable	14	22,211	Barnstable	
Dukes	3	3,390	Edgarton	1,369
Nantucket	1	6,807	Sherburne	

The western parts of this state are intersected with ridges of mountains, one of which, called Hoosack mountain, has an elevation of 3500 feet above the sea. The highest point of land in the state, called Saddle mountain, rises to the height of 4000 feet above the sea. The western side of Mount Holyoke, three miles from Northampton, is composed of basaltic columns, extending ten or twelve rods, and are from 60 to 100 feet high. The diameter of the hexagonal prisms is from two to five feet. The valley of the Connecticut, from two to twenty miles wide, is a very rich and delightful country. The interval-land, in the three townships of Hadley, Northampton, and Hatfield, exceeds 10,000 acres, all visible from a single spot. The predominating soil of the hills and mountains is a brown loam, mixed with sand, gravel, and clay. The soil of the south-eastern counties is in general light and sandy.

The farms in this state are generally from 100 to 200, and seldom exceed 300 acres. The productions are, Indian corn, wheat, rye, oats, barley, buckwheat, potatoes, hemp, flax, hops, and pumpkins. The average crop of Indian corn is about 28 bushels per acre, though the well cultivated interval-lands yield from 60 to 80 bushels. The average crop of rye is about 12 bushels per acre; that of wheat 15 bushels; that of oats 15; that of potatoes, in good land, 200 bushels. The fruits chiefly cultivated are apples, peaches, pears, quinces, plumbs, and cherries.

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* See Wren's *Parentalia*, p. 306.

† MS. Register of William Molart, Prior of Canterbury, p. 28.

‡ See the Lives of Leland, Hearne, and Wood, vol. i. p. 96, 104.

The principal articles of manufacture in this state are cottons, articles of leather, ardent spirits, tanned leather, cordage, wrought and cast iron, nails, woollens, ships, straw bonnets, cabinet work, slit iron, rape oil, soap, muskets, brass and copper, jewelry, bricks, carriages, duck, &c. There were 8 factories for muskets; 16 mills for malt; 36 factories for wrought nails; and numerous saw mills. A manufacture of chemical and medicinal articles was established at Salem in 1812. The total amount of the manufactures of Massachusetts, in 1812, was 18,536,933 dollars.

Massachusetts is one of the most commercial states in the union. It has more than three times as many tons of shipping as any of the rest, and about a third part of the whole that belongs to the United States.

The chief exports are, flour, corn, rice, cotton, tobacco, bread stuff, beef, pork, bacon, lard, butter, cheese, fish, oil, spermaceti, whalebone, lumber, naval stores, beans, pease, potatoes, apples, candles, soap, New Orleans sugar, loaf sugar, hops, wax, furniture, beer, boots and shoes, rum, gin, linseed oil, cables and cordage, nails, iron, cotton yarn, vinegar, &c.

The imports are, dye woods; English, Indian, German, Russian, French, Scotch, and Irish piece goods, hardware, wines, spirits, teas, sugars, coffee, cocoa, fruits, spices, molasses, indigo, cotton, cochineal, manufactures of lead, paints, cordage, hemp, porter, segars, cheese, candles, nails, iron, &c. In 1810, the total amount of exports was 13,013,049 dollars, of which 7,251,277 were of foreign, and 5,761,771 of domestic produce. In 1807, 693 vessels cleared out at the office of the district of Boston and Charlestown.

There are 16 banks in this state, the capital of which amounted, in 1812, to 10,250,000 dollars.

The commerce of this state is greatly aided by several excellent canals, the principal of which is the Middlesex canal, 25 miles long, which extends from Boston to the river Merrimack, and was completed in 1804, at the expense of 550,000 dollars. Montague canal, South Hadley canal, and Essex canal, do not exceed 4 miles in length.

Boston, the chief town of Massachusetts, has been fully described in a separate article. In the year 1814, the population of Boston was 34,000. The public library now contains 3000 volumes. An atheneum was established in 1815, by a private subscription of 43,000 dollars; and a Linnean Society in 1813. SALEM will be described in a separate article. *Beverley* is a commercial town concerned in the fisheries. It has three Congregational churches, one Baptist, a bank, and 4600 inhabitants. *Marblehead*, built on a peninsula, has a good harbour, two Congregational churches, one Episcopalian, one Baptist, a bank, and 5900 inhabitants. *Newburyport* is reckoned one of the most beautiful towns in the United States, and is the third commercial town in Massachusetts. It has a safe harbour; and seven churches, a court-house, a gaol, a bank, and ten public schools. The streets are wide and handsome, and cross each other nearly at right angles; and the houses are elegantly built. The population is 7634. *New Bedford* has 5651 inhabitants; and *Ipswich* 3569. *Charlestown* is connected with Boston by a wooden bridge 3846 feet long; and has an admirable state prison, and 4959 inhabitants.

The principal rivers in this state are, the Connecticut and Merrimack. The Connecticut has already been described under CONNECTICUT. The Merrimack has also been described under NEW HAMPSHIRE. *Ipswich* river, which rises in Middlesex county, is navigable as high as the village of the same name. *Charles* river, which also rises in Middlesex, has a course of 50 miles, runs into Boston harbour, and is navigable 8 miles from the sea by boats.

The principal islands are, Martha's Vineyard and Nantucket. The former is 16 miles long and 8 broad, and, in conjunction with the neighbouring islands, forms Duke's county. Nantucket island is 15 miles long, and four broad, and constitutes the county of that name. Elizabeth islands are formed by a row of islands about 18 miles long.

Iron ore abounds in different parts of the state. Copper ore is found at Leverett; lead ore at Southampton; black lead at Brimfield, in Hampshire; sulphuret of antimony near South Hadley; elastic marble at Pittsfield; slate in Bernard's town; soapstone in Middlefield; limestone in Berkshire; serpentine near Newburyport. There are mineral waters in the town of Sym, and also at Boston and Brighton.

There are two colleges in Massachusetts, namely, Howard College, founded in 1638, with a library of 17,000 volumes, and about 225 students in 1811; and William's College, in Williamstown, founded in 1793. Philip's Academy, in Andover, was founded in 1778; and Drummer Academy, in Newburgh, in 1756. See Morse's *American Geography*, p. 134, and Warden's *Account of the United States*, vol. i. p. 285, Edin. 1819.

MASSILLON, JEAN BAPTISTE, the celebrated French preacher, was born at Hieres, in Provence, in the year 1663. He was descended from obscure parents, and entered the congregation of the Oratory at 17 years of age, with no other recommendation than his opening, but unassuming, talents. He very soon attracted the notice of his superiors, by whom he was destined for the pulpit; and, in obedience to their judgment, more than his own wishes, applied himself to the study of eloquence. Having pronounced the funeral oration of Villeroy, archbishop of Lyons, and Villars, archbishop of Vienne, his fame spread so rapidly, that he was invited to Paris by the Cardinal de Noailes, who placed him in the seminary of St. Magloire, and promised to take charge of his fortunes. His first sermons produced all the impression which had been anticipated; and, as soon as he appeared in the churches of Paris, he eclipsed all his predecessors in the eloquence of the pulpit. In 1699, he was appointed to preach at Versailles before the court, and the exordium of his first discourse before Louis XIV. has been considered as a striking union of eloquence, address, and apostolic fidelity. "Sire," he said to the king, "if the world were here speaking to your majesty, it would not say to you, 'Blessed are they that mourn;' (the words which he had chose in his text) Blessed, would it say to you, the prince who has never fought but to conquer; who has filled the universe with his name; who, in the course of a long and flourishing reign, has enjoyed with splendour all that men admire—the greatness of his conquests, the love of his people, the esteem of his enemies, the wisdom of his laws—but, Sire, Jesus Christ speaks not as the world speaks." In 1704 he made his second appearance before the court with still greater applause from the monarch. After the death of Louis

XIV. he was appointed by the regent to the Bishopric of Clermont in 1717, and, in the following year, was called to preach before the young king, who was then only nine years of age. On this occasion he composed, in less than three months, those discourses which are known under the name of *Petit-Careme*, and which are regarded as the master-piece of their author. In the year 1719 he was admitted a member of the French academy, but almost immediately afterwards departed to his diocese, where he continued, in the most exemplary manner, to discharge the duties of his office, with little interruption, till his death in 1742.

Masillon, in his personal character, was distinguished by the most unaffected humility, and does not appear to have ever been intoxicated by the celebrity which he acquired; though, at the same time, he was not insensible to the commendations with which he was overwhelmed. To one of his brethren, who was congratulating him on the success of his discourse, he replied: "The devil has told me all that already, more eloquently than you." He made no pretensions to superior sanctity, but acknowledged the existence in his own heart of all the evils which he exhorted his hearers to combat. When some had expressed surprise, how a person, devoted by his office to retirement, should know the world so well as to be able to draw such correct pictures of the passions, especially of self-love, he candidly replied, "I have learned to draw them by studying myself." His gentleness, politeness, and cheerful disposition, rendered his society peculiarly attractive, and endeared him in the highest degree to his friends, but more particularly to the clergy and people of his diocese. In his office of bishop he applied himself, with unremitting and affectionate attention, to promote the welfare of all who were placed under his charge. He employed, for the instruction of the poor, the same talents which had attracted the admiration of the great; and perhaps the most eloquent of his discourses are those which he addressed to his clergy, in which he inculcates upon them those virtues of their office, of which he presented them, in his own conduct, so engaging an example. He adorned his principles and his office by the most disinterested beneficence and active humanity; and, besides expending the greater part of his income in relieving the indigent, he often employed his influence with the court, to procure for the inhabitants of his diocese a diminution of the imposts to which they were subjected. But, while he so ably advocated the cause of religion by his talents, and adorned its principles by his example, he was at once most zealous and resolute in suppressing the superstitions by which it was degraded in his district; and, when the clergy of Clermont were afraid to publish his prohibition of certain unbecoming processions, to which the inhabitants were greatly attached, he ascended the pulpit in person, and proclaimed his own edict to the tumultuous audience.

His productions for the pulpit, which have been so generally admired, are remarkable chiefly for the united elegance and simplicity of the language; for the affecting eloquence of the sentiments; and for the unfeigned earnestness which appears in the preacher to impress the truths which they discuss upon the hearts of the hearers. This last quality serves to excuse that sameness of idea which is so often observed in many of them, recurring again and again under a rich variety of expressions and illustrations. His manner as a preacher was well suited to the style of eloquence which he had adopted. "Upon entering the pulpit," says D'Alembert, "he appeared deeply penetrated by the great truths which he was about to utter, with his eyes cast down, a modest yet collected air, without any violent motion, and almost without any gestures at all, but animating the whole with a touching voice of sensibility, he diffused over his audience that religious emotion which his exterior indicated, and made himself be heard with that profound silence, by which eloquence is better praised than by the loudest applause." The celebrated actor Baron, on leaving the church after hearing one of his discourses, said to a friend who accompanied him, "This man is an orator, and we are only players." The effect of his sermons, delivered in this manner, is said to have often been extraordinarily impressive. When preaching his sermon, "On the Small Number of the Elect," the whole audience, at a certain passage of it, was seized with a sudden and violent emotion, so that almost every person half rose from his seat, by a kind of involuntary and simultaneous movement.

An edition of his works was published by his nephew at Paris in 1745, in 14 vols. 12mo. containing sermons for advent, lent, funeral orations, and other discourses; the ten sermons known by the name of Petit Careme; Conferences Ecclesiastiques, delivered in the seminary of St. Magloire, after his arrival at Paris; charges addressed to the clergy of his diocese; and paraphrases on several of the Psalms. A collection of his most striking passages was published at Paris in 1748, in 1 vol. 12mo. by Abbe de la Porte, entitled *Pensées sur differens sujets, de morale et de pieté.* (*q*)

MASSUAH. See ABYSSINIA.

MATERIA MEDICA.

MATERIA MEDICA is an auxiliary branch of the science of Medicine, which treats of the nature and properties of all the substances that are employed for the cure of diseases. By some writers the term has been used in a more comprehensive sense; and has been made to embrace an account of all the means, of whatever kind, which have been adopted for this purpose; thus including the effects of diet, climate, air, and in short of all those circumstances which may in any way be considered as affecting the health. But we think that this method of extending the term is both literally incorrect, and is also less commodious than the plan which we propose to adopt, of restricting it to those substances of a material nature which are generally denominated Medicines.

With respect to the history of this department of medical science, and the progress which it has gradually made to its present improved state, we shall here take only a very brief view of the subject, reserving a more particular account of it for the historical part of the article MEDICINE. In fact, the history of Materia Medica is so interwoven with that of Medicine generally, that were we to give a complete view of the former in this place, it would either lead us into much repetition, or we must leave the latter, which is the leading and more important topic, in a very imperfect state.

The earliest writer who appears to have devoted himself exclusively and specifically to the study of the materia medica is Dioscorides; but his account of remedies, and of their medical qualities, is thrown together without order, and is totally devoid of accuracy or discrimination. The writings of this author abound with examples of what may be called false experience, where powers or qualities are ascribed to substances which are altogether imaginary and without foundation; and they exhibit so many instances of credulity and superstition that no person in the present day would place any confidence in his statements, or expect to obtain from them any real information. Galen, in different parts of his multifarious works, has suggested a methodical classification of remedies; but it is derived entirely from his hypothetical opinions respecting the qualities of the elements of bodies, and, therefore, according to our present ideas upon the subject, is to be considered as entirely fallacious. The Arabians, although they introduced many new articles into the practice of medicine, and more especially enriched it with chemical preparations taken from the metals, still adhered to the Galenic theory. They maintained the four qualities of hot, cold, moist, and dry, with all their combinations and modifications, and cannot be considered as having in any degree promoted the science of the materia medica, although they made some additions to it as a mechanical art. When the chemical doctrines of pathology were broached by Paracelsus, it gave a new turn to the theory of every department of medicine; but the immediate alterations that took place can scarcely be regarded as improvements. The hypothesis of the Galenists, although founded upon false principles of reasoning, and an imperfect deduction from facts, had still a semblance of science, whereas the alchemists, after they had overthrown the theory of their antagonists, fell themselves into the grossest errors of credulity and enthusiasm. A certain portion of superstition seems almost necessarily to attach itself to medicine, and has always been found connected with it from the earliest times. Generally, however, it appears merely to have shared in the common frailties of the contemporary age, whereas, during this period, it was involved in peculiar darkness. The wildest dreams of astrology and magic were applied, even by the most learned men, to the explanation of the action of remedies; and the three kingdoms of nature were ransacked for substances the most extravagant, the most rare, or the most disgusting, conceiving that their medical virtues must bear an exact ratio to these qualities.

For about two centuries the science of medicine generally, and that of the materia medica in particular, was almost entirely occupied with the controversies between the chemists and the Galenists; the former deriving their ideas from the doctrines of the followers of Paracelsus, and the latter being the opposers of the new opinions, who still adhered to the tenets of the ancients. A more particular account of this controversy will be found under the article MEDICINE; at present we shall only remark, that wild and ridiculous as were the professions of the alchemists, still it may be considered as eventually a fortunate circumstance for the progress of knowledge, that something occurred to check the unreasonable attachment that then subsisted to all the hypotheses of the ancients, and to rouse the torpid faculties of the human mind, which seemed to be entirely paralysed by superstitious bigotry for every opinion that was thought to be sanctioned by the authority of Galen. The earlier attempts of the chemists to reform, or rather to alter the materia medica, consisted principally in the introduction of a set of medicines which were much more powerful than those which had been previously in use. Instead of the multifarious masses of what were called simples, which composed the prescriptions of the Galenists, consisting principally of vegetable decoctions or extracts, the chemists employed metallic preparations, distilled spirits, and tinctures. One of the articles which gave rise to the warmest controversies of that period was antimony. This substance was brought forward by the chemists with the most extravagant eulogiums, and was as violently condemned by the opposite party as a virulent and deadly poison.

It was not until the beginning of the 17th century that these violent feuds began to subside, and that men entered upon the discussion with their minds in such a state as to have any chance of discovering the truth. This happy revolution was effected in a gradual manner, partly in consequence of the general diffusion of science which was taking place through the western parts of Europe, and more particularly from the improvements which were made about this period in chemistry and natural history. The alchemy of the dark ages, with all its bigotry and mysticism, now assumed the form of a philosophical investigation into the properties of matter, and the superstition and credulity which had been connected with the virtues of medicines, was gradually refined into a rational enquiry respecting their growth and production, with an examination of their physical properties, and their action on the living body.

But although mankind had discarded many of their former prejudices, and had entered into a more correct path than that of their predecessors, still a long time elapsed before they were able to shake off all their errors. The first effect of the improvement which we have been describing, was a kind of union between the parties, who were each of them anxious to lend their assistance to promote the progress of knowledge. The earliest attempts that were made in consequence of this co-operation, were principally directed to ascertain the virtues of vegetables, by subjecting them to chemical analysis; but the analysis that was employed was almost exclusively confined to the action of fire, or, as it was called, destructive distillation. The French, who had acquired the most experience in chemical manipulations, ardently engaged in this pursuit, and submitted a vast variety of vegetable substances to this kind of examination. The result, however, of all these trials, from reasons which we are well able to comprehend, was entirely useless; for, whatever difference there might be in the sensible or medical properties of the substances that were examined, it was soon found, that, by the operation of fire, nearly the same ingredients were procured from all of them.

These abortive attempts at chemical analysis, were continued with much assiduity until about the middle of the last century, when a different method was adopted, for which we are chiefly indebted to the German chemist Neumann, and to Cartheuser. The *Fundamenta Materiæ Medicæ* of this latter author, may be considered as among the most respectable works on the subject which had appeared at the time of its publication, while the science of chemistry in general, and especially that of vegetable substances, was materially advanced by the labours of the former. Neumann entirely rejects the action of fire, as employed for the purpose of destructive distillation, and substitutes for it the agency of different menstrua, so as to separate the various constituents from each other into the several classes of salts, oils, resins, &c. in a way which, although imperfect, compared with the present state of chemical science, was greatly superior to that of his predecessors. After Neumann and Cartheuser had pointed out the proper method of proceeding in the application of chemical analysis to organized bodies, the subject was taken up by various experimentalists in different parts of Europe. France, as she took the lead in chemical science generally, has been the most distinguished in this particular department of it; and even in the present day, we are indebted to her for a great portion of our most interesting information on this topic.

As the study of natural history became an object of more general attention, and the observations that were made began to partake of the state of general improvement, which was gradually extending itself to every branch of science, the knowledge of medical substances was enlarged and corrected, and the errors which had been entertained respecting them were progressively, although slowly removed. The earlier botanists, when describing the external characters and sensible qualities of plants, usually added an account of their reputed virtues in medicine, and attempted to arrange them according to their obvious effects upon the body; and although their first efforts were frequently incorrect and ill directed, they led to more accurate ideas upon the subject, and are consequently entitled to our notice. In this point of view we may regard the labours of Gesner, the two Bauhins, and especially of Ray, who was one of the first naturalists that possessed the true spirit of philosophy. Improvements were gradually added by their successors, until the whole science received a new impulse, and assumed a new aspect from the genius of the celebrated Linnæus.

In this very brief sketch of the progress that was made in the knowledge of the materia medica, we shall not attempt to give a regular detail of the different writers who successively exercised themselves upon this topic. Although we may include in the list some of the most learned and industrious men who have adorned the profession of medicine, yet it unfortunately happens, that no department of science was so long in attaining what we should now call a rational state, as that which professes to give an account of the nature and powers of medicines. It was soon found, that all the attempts which were made to ascertain the properties of the articles of the materia medica from hypothetical principles were of no effect; that experience ought to be the sole guide; and that the only method which promised any success, was to collect from the best sources of information the most authentic facts, and afterwards to arrange the facts thus obtained in a scientific form. The plan of proceeding was correct, but the execution of it was miserably defective. It would seem, that no sooner did the authors undertake this office, than they resigned themselves to a state of complete credulity, and received implicitly every thing that was told them, without selection or discrimination. One of the earliest of the moderns, who for a long time was referred to as a standard authority, is Shroeder; but he seems to have satisfied himself with merely copying from the ancients, and transcribing all the tales that were told him by his cotemporaries. Nor can we bestow much more praise upon Pauli of Copenhagen; nor upon Wedel, who, although for many years holding a professorial chair at Jena, and much celebrated for his learning, has given his sanction to all the follies of astrology and magic.

We may observe, indeed, some little progress towards a more rational view of the subject, in the essay of Hermann, professor of botany at Leyden, who published on the materia medica early in the last century; and about the same period a more correct spirit began to show itself in France, where the works of Chomel, and still more of Geoffroy, manifested a considerable improvement in general science, as well as a decided advance in the art of discrimination. Still, however, even in that country, a vast mass of superstition and credulity remained; of which we cannot bring forward a stronger example, than the second part of the *Synopsis* of Lieutaud, which was published in 1765, a writer who, from his general character and his situation, may be regarded as possessing all the knowledge of his age and nation.

We think that our own country may justly boast of having produced the first rational work on the materia medica, in which a due discrimination was attempted between real and false experience, and where nothing was asserted respecting the qualities or powers of medicines which was palpably false or ridiculous. We refer to the publication of Lewis, a work which caused a greater actual advance in the state of the science than any which had preceded it, and which, as it was afterwards improved by Dr. Aikin, may still be regarded a very valuable performance. His reputation has indeed been, in some measure, eclipsed by the still greater merit of the lectures of Cullen on the materia medica, which were published not long after Lewis's treatise, and which we are disposed to consider as perhaps the most ingenious production of that celebrated writer. Among the works of real merit which appeared during the last half century, we must not omit the treatises of Vogel, the learned professor of Gottingen; that of Linnæus, as edited by Schrœber; that of Bergius, the pupil of Linnæus; and the elaborate performance of Murray of Gottingen, with the continuation by Gmelin.

It will not be expected that we should attempt to give an analysis of all the works that have been mentioned. With respect to the earlier of them, they are now to be regarded rather as objects of literary curiosity than of actual value, so we shall pass them by without farther notice; but it may be desirable to give some account of the later productions, and more particularly of the method which the several authors have adopted in the arrangement of their materials. As the classifications that have been formed depend, in part at least, upon the supposed knowledge of the virtues or qualities of the substances, it will be proper to premise a few observations upon the different means that have been employed for ascertaining these qualities.

It is perhaps not easy to determine in what way mankind first acquired their ideas of the supposed virtues of the various substances that were used in medicine. Probably it was, in the first instance, from experience or analogy; but the experience was very limited, and indeed frequently incorrect, and the analogy was often entirely unfounded. By degrees opinions would be adopted that were derived more immediately from theory; but as the theory itself was in almost every instance false, the ideas that were connected with it were necessarily so likewise. Dioscorides professes to have derived all his knowledge of the properties of substances from the experience either of himself or of others; and, fallacious as this experience frequently was, it may, upon the whole, be considered as leading to errors of less magnitude than the hypotheses of Galen. The opinions of the chemists, although professing to be founded upon experiment, must be considered as comparatively in a very few instances only the legitimate result of correct observation. They were in reality derived from the philosophy of the times, or at least from what usurped that title; and accordingly we find that different writers ascribed different qualities to substances, or explained their operation on the living body upon the principles of astrology, magic, and all the wildest dreams of superstition.

When a more rational view of the subject began to be taken by the writers of the last century, these doctrines were, for the most part, discarded, and were gradually superseded by more correct, although still by imperfect views of the subject. The chemical physiology was at that period the prevailing doctrine; and as it followed, from the principles of this hypothesis, that medicines act by their chemical properties, it seemed a natural and proper object of inquiry to subject the articles of the materia medica to chemical examination, in order to discover in what particular parts their chemical qualities resided, or what were the constituents which produced certain effects upon the system. This, as we have observed above, was first attempted by the action of fire alone, and afterwards by that of various chemical re-agents. No very important information was obtained from either of these sources with respect to the exact object of pursuit; but by the latter of them we have obtained much useful knowledge respecting the chemical constitution of the various substances employed, and we have been enabled to make many valuable additions to the art of pharmacy. In many cases we have learned how to extract the most active ingredient from a compound mass, and thus to employ certain medicinal agents in a more pure or concentrated state; and by the operations of chemistry we have likewise been enabled to form a variety of new combinations, possessed of very valuable qualities, which compose some of the most important articles of the materia medica.

When the science became attended to by naturalists, they were more disposed to regard the external and sensible properties of the articles, and to consider them as objects for classification and arrangement, upon the same principles with the other bodies in nature. The earlier botanists generally considered it an essential part of their business to enumerate the supposed medical virtues of plants; but as they were themselves frequently unacquainted with medicine and pathology, they were obliged to rely upon the information of others, and were thus led to fill their works with the grossest errors and absurdities. The authority of their names tended unfortunately to give a sanction to their errors; they were transcribed from one work to another, and preserved with a kind of religious veneration, without inquiring into the sources whence they originally proceeded, or the grounds of their credibility. The great Linnæus, by whom the whole range of natural knowledge was reformed and re-modelled, contributed materially to the purification of the materia medica. He rejected nearly the whole mass of tradition that had been accumulating for ages, established a correct examination of the sensible properties of substances, and instituted an inquiry into the correspondence between their sensible and their medicinal qualities, and upon the connexion or relation which they bear to each other.

In this, as in the attempts that were made to obtain a knowledge of the virtues of plants by chemical analysis, the advantage that has resulted from the examination was rather collateral, than exactly that which the inquirers proposed to themselves. It is not often that we are able to predict the medical properties of a plant from the place which it occupies in a botanical arrangement, or even from those characters which are more especially the objects of attention to a naturalist. Even when plants have been arranged in what are called their natural families, we find it impossible to form more than a conjecture respecting their operation upon the living body, and we perpetually meet with the most remarkable exceptions to any general rules which we might be disposed to deduce from classifications of this kind. There are indeed some few cases in which analogy may perhaps have led to the first trial of the virtues of a plant, but the instances of this description are so rare, that we could not venture upon any experiments of this nature without the greatest caution. In short, we may conclude, that the only advantage which we are to expect from the assistance of natural history, is to ascertain correctly the identity of the substances which we employ, an advantage which, however, we shall not be disposed to undervalue, when we reflect upon the great uncertainty that attends all the descriptions of the older writers on the materia medica, contrasted with the accuracy and precision of the moderns. So much indeed is this the case, that a considerable part of the experience of the older authors is rendered of comparatively little value, from the difficulty, or indeed impossibility, which we find in determining to what substances their descriptions refer.

We shall not think it necessary to dwell long upon the method that has been adopted by some writers of great eminence, and even by Linnæus himself, of attempting to ascertain the medical qualities of bodies by their sensible properties, especially by their taste and odour. It appears indeed, that, to a certain extent, we are able to trace a connexion between the sensible and medical qualities of substances; but the exceptions to any general rules that we can lay down are so numerous, as to render the observations more a matter of curiosity than of real utility. In short, we are irresistibly led to conclude, that the only certain ground of proceeding is experience. Accordingly we find, that even those writers who have attempted to deduce any general rules from other sources, have ultimately been under the necessity of appealing to experience in each individual case, while, on the contrary, in the greatest number of instances, experience is the only circumstance to which we can have recourse for forming our judgment, and is indeed always considered to be equivalent to all the rest, or rather entirely to supersede them.

It is, however, much to be regretted, that, in employing this mode of investigation, mankind have generally proceeded upon a very erroneous estimate of the proper use that is to be made of it, or rather have taken very inadequate methods of obtaining it. Hence we find, that of the multitude of facts which profess to be built upon this foundation, only a very few have been actually found to maintain their credibility; so that in modern times, a large share of the labour and attention of those who have written on the materia medica, has been necessarily employed in examining into, and generally in discarding the false or pretended experience of their predecessors. Every one must be aware of the proneness of mankind to believe and propagate wonderful tales, of all kinds, without due examination, and not unfrequently entirely to invent them from their own imagination; we cannot, therefore, be supprised that the materia medica, like every other science, which must ultimately rest upon testimony, is liable to be encumbered with numerous errors and falsehoods. But we find, as a matter of fact, that it has been peculiarly unfortunate in this respect; so that we may venture to affirm that no one department of knowledge has been so clogged with false facts and false experience, as that which professes to treat upon the virtues and properties of medicinal substances.

Nor indeed is the reason of this difficult to be comprehended. In the first place, when we form a judgment respecting the medical qualities of a substance, or its operation upon the body, it is not a *single fact* only that we have to ascertain, but we have to notice a number of facts that are connected together, and this frequently by an obscure bond of union. In the 2d place, it is scarcely possible to observe or announce the train of facts, without joining to it, or implying in it a certain degree of hypothetical reasoning; and, in the 3d place, there are very few cases in which the supposed facts can be noticed in a detached form, or in such a manner that we can separate their influence from that of other contemporary causes, and assign to each their due share of effect. These may be regarded as the general sources of error and difficulty in the inquiry, and if we descend to particulars, we shall find other circumstances equally powerful in misleading the judgment, or in obstructing it in its search after truth.

The most important, of what we may denominate partial causes of error, is the nature of the sources from which, in a great number of cases, our information is obtained. It is seldom, in the first instance, derived from men of science; frequently it originates from popular tradition, or from reports that have been circulated among the vulgar: and even when it proceeds from a more respectable quarter, it is almost always from those who are little conversant with philosophical investigation, or with the correct method of conducting experiments. In the 2d place, it is but seldom that those who are the best adapted for this kind of inquiry have the means of putting it into practice. Experiments upon the operation of medicines are rarely of a direct nature; we are under the necessity of making them with great caution, and we are generally obliged to arrive at our conclusions by combining a number of circumstances, each of which, taken singly, bears only in an indirect manner upon the main question. We may farther observe, in the 3d place, that even where we are justified in making a direct experiment upon the operation of a medicine, we can never proceed with the same advantage and confidence, as when we operate upon inanimate matter. Although we may be thoroughly acquainted with the physical properties of the substance which we employ, we can never be certain of the state of the living body on which it operates. This is not only different in different individuals, but is perpetually varying in the same individual, so that it is only by the comparison of a great variety of cases, and those placed under a great variety of circumstances, that we can venture to generalize our conclusion, or suppose that we have arrived at what can authorise us in laying down any certain positions.

We are aware that many other causes of error might be enumerated, but we apprehend that enough has been said to account for the state of this branch of medical science, and to warrant us in our scepticism respecting the alleged operation of medicines. We cannot indeed leave this topic without making one farther observation, which we make with reluctance; but we are certain that every one who is competent to form an opinion upon the subject will allow it to be just, that, besides the errors into which mankind have fallen through inadvertency, or in consequence of their adopting wrong principles of judgment, the materia medica has been one of the most fertile sources of wilful deception. The hopes and fears of mankind are daily put in requisition to supply the demands of avarice and selfishness, while the uncertainty which necessarily attaches to the subject, and the real difficulty which there is in acquiring correct information, affords to the designing impostor the finest field for knavery and deception. Too many proofs of the truth of our remark daily occur even in this enlightened age, and in this enlightened country; for, although the fact be generally admitted, still the great bulk of mankind rush into new snares whenever they are spread before them, as if they were eager to become the dupes of self-deception.

In forming an arrangement of the articles of the materia medica, it is not merely necessary to ascertain the virtues or quality of the substances that we employ, we are likewise to inquire into the way in which the living body, on which they are intended to operate, is affected by them. Although the living body be not deprived of the properties of inanimate matter, we know that it derives its most essential qualities from powers or faculties of a specific kind, which are peculiar to itself. A more full development of the nature of these powers or faculties will be given in the articles MEDICINE and PHYSIOLOGY, but we shall make a few general observations in this place, and shall likewise prefix some remarks on the mode of action of different classes of remedies, as they successively pass under our review.

In the first place, we are always to bear in mind, that there are comparatively few cases, in which we can form any conclusion, or even draw any inference, respecting the operation of a medicine on the living body, from its action on inanimate matter. There are, indeed, some few instances in which a substance seems to act directly from its chemical, and even perhaps from its mechanical properties; but these are rare, and of little importance, compared to those in which the action is upon the vital powers of the system, and is of course essentially different from what it would be upon the same body when deprived of life. In the second place, it seldom happens that we can produce any one direct or primary effect, without, at the same time, inducing a train of secondary consequences, which, so far as respects their medical action, are often more important than the primary operation itself. We may observe, in the third place, that in some instances, the sensible operation of a medicine is completely different in one individual from what it is in another, and even in the same individual, is quite different at different times, so that, in arranging medicines according to their operations on the body, we are perpetually liable to meet with anomalies and inconsistencies, which interfere with the best constructed system, and introduce endless exceptions into the best established general principles. Another observation that we have to make is, that the apparent action of medicines is sometimes entirely reversed by an alteration of the dose in which they are given, or the manner in which they are applied; and, in the fifth place, we frequently find that the powers or qualities of medicines are entirely changed by their combinations with each other, and that by certain mixtures, new qualities are, as it were, produced, which are of the most active kind, and of the most essential importance in the practice of medicine.

We shall now proceed to give an account of some of the systems of materia medica that have been proposed by the most distinguished authors of the last half century, the period during which the science has undergone its chief improvements. One of the first writers, of any degree of eminence, who attempted a scientific method of arranging remedies, according to their medical qualities, is Vogel; and as a classification nearly similar to that which he proposed has been adopted by many of the later authors, it may not be improper to give a sketch of his system. All substances, as he observes, act either upon the solids or the fluids, a circumstance which gives rise to his first great division; in the next place, it is supposed that those remedies which act upon the solids must either change their texture or alter their motions; the first, such as change the texture of the solids, do this, either by relaxing it, by hardening it, or by destroying it, and thus give rise to three classes of remedies, which are denominated, from their supposed effects, relaxants, indurants, or inflamants. Those bodies, which alter the motion of the solids, must do it either by increasing it or diminishing it, and hence are styled respectively, tonics, or sedatives. The 2d division of remedies, those which act primarily upon the fluids, must operate, it is conceived, either by producing some change in their quantity or quality, when they are styled alterants; or by discharging them from the body, when they are called evacuants. These classes of remedies are modified according to the way in which they are used, or the method of their application. Relaxants, when simply applied to the surface of the body, obtain the name of emollients, but when they are used for the purpose of converting stagnant humours into pus, they are called maturants. Of the remedies which are employed for the purpose of exciting inflammation, there are several varieties; when they merely cause redness in the skin, they are called rubefacients; when serous vesicles, vesicants; if they destroy the fibrous structure of any part, they are called cathæretics; if they act particularly upon the flesh, they are styled excharotics; if upon the skin exclusively, corrosives.

The tonics are arranged under several different heads; those which increase the contractile power of the solids, without producing any sensible change in their structure, are called indifferently, corroborants, analeptics, or nervines. If the contraction be in so great a degree as to indurate the solids and condense the fluids, they are called astringents; if they produce the condensation of parts, which had been divided or wounded, they become traumatics or sarcotics; if they suppress the flow of blood, stiptics; if they transfer the fluids from the external to the internal parts, by the contraction of the former, they are repellents; if they remove a collection of stagnating fluids, by a kind of insensible dispersion, they become discutients; and lastly, the titles of stimulants and alterants, are applied to such remedies as excite an increased flow of the fluids towards the part where the substances are applied. Sedatives may be used either externally or internally; in the first case, they are termed paregorics, a meaning of the term different from that in which we now employ it, while the internal sedatives are denominated antispasmodics, anodynes, hypnotics, and narcotics, according as they remove spasm, merely alleviate pain, relieve it by gentle slumber, or by profound sleep.

There are many species of alterants, as their number was augmented in proportion to the various morbid states, to which, according to the humoral pathology, the fluids are subject; when they were supposed to contain an excessive quantity of acid, we had absorbents to remove or neutralize the acid, and to counteract other morbid conditions, we have antiseptics, bezoardics, alexipharmics, and antidotes. The consistence of fluids, as well as their other qualities, may be likewise affected by alterants; if too thick, we use resolvents, if too thin, condensers or coagulants; and for the purpose of removing morbid heat and cold, we have refrigerants and calefacients. But the most important and varied of the great class of remedies that act upon the fluids are, the evacuants, and these are arranged partly according to the organ which they affect, and partly according to the degree of their operation. When they act upon the stomach, they are called emetics, when upon the bowels, purgatives, laxatives, and aperients, (lenientia,) terms which are used to denote the gradation of their effect. Remedies which increase the cutaneous perspiration are styled diaphoretics if gentle, and sudorifics if more violent in their operation; those which increase the flow of urine are diuretics, of saliva, salivants; and when they accomplish this by remedies applied topically to the mouth, they acquire the name of apophlegmatics. Remedies which increase the evacuation of the mucous fluid from the nostrils are ptarmics, errhines, and sternutatories; those which promote the discharge of the menses, the lochia, and the placenta, are respectively styled emmenagogues, aristolochics, and echolics. Besides these, we have anthelmintics, lithontriptics, and carminatives, appropriated to the discharge of worms, calculi, and flatus, and various other remedies, which serve either to act specifically upon certain states of the system, or which have been adopted upon empirical grounds.

Considering the state of medical theory when Vogel wrote, comparing his ideas with most of his predecessors, we must allow him the merit of having advanced the science, although it was left in a state requiring much farther emendation. Indeed, it may be asserted, that, from various causes, no department of medicine was in so degraded a state as the materia medica; for, in addition to the erroneous opinions which it contained, in common with the other branches, it was, from its nature, peculiarly liable to become the receptacle of the grossest folly and credulity. As a specimen of this state of things, we shall transcribe from Vogel's work, a list of the "parts of animals" which have been at various times employed in medicine, arranged in three divisions; the first comprehending those that were then in use, about the middle of the last century; the 2d, those which were rarely employed in medicine; and the 3d, those which he considers at that time as being obsolete. Our readers will, no doubt, unanimously coincide with the author, in the propriety of placing every one of the articles in this last division that are now found there, and we may be equally confident that they would have made it considerably larger. It must, however, be remarked, that long after the publication of Vogel's work, several of these prescribed substances are retained in different pharmacopœias, without any mark of reprobation; and we believe are, at this day, to be found in some of the most modern lists of the materia medica that have appeared in France and Germany.

"Partes animalium. 1. Usitatæ. Canis axungia. Castoreum. Cervi cornu. Cervi sevum. Concha. Hirci sanguis. Hirci sevum. Hirudo. Mater perlarum. Moschus Porci axungia. Sepiæ os. Tauri fel. Vaccinum lac. Vulpis pulmo. Zibethum.

"2. Infrequentes. Alcis cornu et ungula. Anguillæ hepar. Anseris axungia. Apri dens. Cancrorum chelæ. Cervi priapus. Cochliæ testæ. Ebur. Equi testiculus. Leporis axungia et talus. Lucii mandibula. Maris alpini axungia. Perdicis plumæ. Vulpis lingua. Ursi fel et pinguedo.

As we proceed to the 3d class, we rapidly advance in the career of absurdity. Album Græcum. Asini sanguis. Carpionis lapis. Cati sylvestris axungia. Ceti priapus. Dentaliorum testæ. Gallinæ tunica interior ventriculi. Hippopotami dens. Hominis axungia, corium, cranium, lac, saliva, sanguis, urina. Lupi caro, dens, hepar. Manati lapis. Os de corde cervi. Pavonis stercus. Percarum lapides. Rhinocerotis cornu. Scarabæi cornu. Secundina humana. Tauri priapus. Taxi axungia. Vaccæ urina. Unicornu." It is to the credit of this country, that this ridiculous and disgusting list of compounds has long been banished from our pharmacopœia. Yet, it may appear remarkable, and at first view it is not to be reconciled with the ordinary operations of the human mind, that for the greatest part of them, the authority of men of learning and of professional skill was adduced, and that the same individuals to whom we are indebted for many important discoveries in anatomy and physiology, gave their sanction to this barbarous condition of the materia medica.

At the time when Vogel published his treatise, Cullen was already engaged in his lectures, and, as was the case in every department of medical science to which he directed his attention, he contributed very considerably to purify it from the antiquated errors which remained attached to it. By discarding many of the old pathological doctrines, he was led to strike out several classes of remedies, to others he applied new names, corresponding to the more correct indications which he established for the cure of diseases, while he greatly reduced the number of the articles. Cullen professes to proceed upon strict theoretical principles in his arrangement of remedies, although he admits that some parts of the subject are still obscure, and some of the indications of doubtful existence. He begins by dividing substances into two great classes, according as they act immediately upon the solids or the fluids, an arrangement, which, it must be confessed, at its very outset, is inconsistent with the pathology of solidism, which he took so much pains to establish. The first class, he then divides into two genera, those which act upon the simple fibre, and those which act upon the moving or living fibre. Under the first class of remedies, those that act upon the simple solid, there are three divisions; nutrientia, the substances which afford additional matter to the system, and which belong rather to dietetics than to materia medica; astringents, those which increase the cohesion of the particles of the fibre; and emollients, those which diminish this cohesion. Of astringents there are several species enumerated, but there are only two which possess any decided characteristic properties; exsiccants, those astringents which are applied externally; and tonics, those which act upon the fibre, so as to give it that power which is necessary to the performance of its appropriate functions. It may be doubted, whether it be strictly proper to regard any of these substances as acting exclusively, or even principally, upon the simple fibre, but, with respect to the last of them, the tonics, the idea is certainly incorrect; they are applied through the medium of the stomach and can only act constitutionally. Of the remedies which act upon the living solids, the most important class are the stimulants, which increase, and the sedatives, which diminish the vital powers; while, in the third place, we have the antispasmodics, the substances which remove or restrain their irregular motions.

In arranging the remedies which act immediately or primarily upon the fluids, Cullen sets out with the same division that was adopted by Vogel, into alterants and evacuants; the first comprising those remedies which produce a change in the general state of the fluids, and affect "either their mixture or their consistence." According as they are too thick or too thin, we have the attenuants and the inspissants, and with relation to the composition of the fluids, we have demulcents, "to cover and sheathe acrimony," antacids and antalkalines, the objects of which are sufficiently expressed in their denominations, and antiseptics, or those substances which obviate the putrescency of the fluids. Independently of the general objection which may be urged against this whole class, that they suppose the cause of disease to be primarily situated in the fluids, there are particular objections against the individual species. It is very doubtful whether we possess any means by which we can at pleasure either increase or diminish the viscidity of the fluids, while the states of acrimony and of putridity are themselves of very uncertain existence. Evacuants are regarded by Cullen as producing their effect by increasing the quantity of the secreted fluids, and they are arranged, as is usually the case, according to the organs on which they operate, or that to which they are immediately applied. Beginning with the upper parts of the body, and proceeding according to their local situation, we have errhines, sialogogues, expectorants, emetics, cathartics, diuretics, diaphoretics, and emmenagogues. Besides these, there are other classes of substances that belong to surgery, or, at least, which act only topically, or upon the external surface of the body.

Our knowledge of the materia medica received many valuable additions from Lewis, but it consisted more in giving a good account of the natural history of the substances, and in describing their pharmaceutical preparations, than in ascertaining the method of their operation. The articles are arranged merely in the alphabetical order; and, in the subjoined description of their medical virtues, we still meet with a portion of that credulity which we have already remarked on so many occasions, although there are few writers who advanced more upon their immediate predecessors than Lewis. Since the time of Lewis and Cullen, the subject has continued to receive additions from various quarters; and we may perceive in the later publications a gradual correction of the errors of our theory, as well as the accession of new facts; but, for the most part, the writers have proceeded upon the same general principles, and their works may be regarded rather as improvements of the method of Vogel and Cullen, than as exhibiting any original plan of classification.

A complete and fundamental alteration was, however, attempted by Darwin, who, in a great measure, discarding the sensible operations of remedies, or their obvious effects upon the functions, endeavoured to arrange them according to the actual changes which they produce upon the system. All the numerous divisions of Cullen and his successors are entirely omitted, and the whole of the articles of the materia medica are distributed into seven classes, which derive their names from the supposed nature of their operations. They are as follows: 1st, *Nutrientia*, or those remedies which preserve the irritative motions in their natural state; 2d, *Irritentia*, those things which increase the irritative motions; 3d, *Secernentia*, or those remedies which increase the irritative motions that constitute secretion; 4th, *Sorbentia*, those which promote absorption; 5th, *Invertentia*, those remedies which invert the natural order of the successive irritative motions; 6th, *Revertentia*, those which restore the natural order of these motions; and, 7th, *Torpentia*, or those things which diminish the irritative motions.

To understand the ground upon which Darwin builds his theory of Therapeutics, it is necessary to attend to the meaning which he attaches to the term *irritation;* this he defines to be, "a change of some extreme part of the sensorium in the muscles or organs of sense, in consequence of the impulse of external bodies." With respect to his pathological principles, he supposes all diseases to originate from some affection of the sensorium; that the sensorium possesses four distinct faculties or powers; and that irritation is the faculty which results from the impulse of external bodies—whereas the other three, sensation, volition, and association, depend upon the re-action of the different parts of the system on each other. We must refer to the section *Pathology*, in the article Medicine, for the remarks upon this fundamental position of Darwin, that all external agents operate upon the same faculty or power in the system,—a position which we regard as altogether incorrect; but, without insisting upon this point at present, we shall offer some observations upon his seven classes.

With respect to the first class, the nutrientia, we may repeat the objection that we made above, that these bodies ought not to be regarded in the light of remedies, *i. e.* of substances which contribute to the restoration of health, or the removal of disease, but are rather to be regarded as serving for the actual existence or direct support of life. The incitantia may be considered as forming a natural order; but with respect to the two next divisions, the secernentia and the sorbentia, it may be doubted whether there be any substances which possess the specific properties expressed in these titles, and which are, at the same time, confined to these operations; and even if this be admitted, we can still only regard them as species of the incitantia, and not as entitled to form primary classes. With respect to the general arrangement, it may be objected, that the author, after distinguishing two species of incitantia, those which act on the secretory organs and the absorbents, does not proceed in the same way through the other parts of the system, which seem equally deserving of being particularised; as, for example, the arterial and the nervous systems respectively, and perhaps the action of the alimentary canal.

The two next classes, the invertentia and the revertentia, we regard as extremely hypothetical. It may appear not a little remarkable, that in the first of these classes are included most of those substances which have been generally designated under the title of evacuants, and which, by previous writers, have been supposed rather to increase the natural action of the several organs than to invert them. Emetics may, indeed, in a certain sense, be said to invert the natural action of the stomach; but we cannot admit this to be the case with respect to cathartics, errhines, sialogogues, or diuretics. The revertentia nearly coincide with the antispasmodics of Cullen and others; and although the theory of spasm be doubtful, and its cure in a great measure empirical, still we think it a more expressive, and a less hypothetical term than the one adopted by Darwin. The torpentia, in their general object, nearly coincide with the sedatives of former writers, although there is a very great difference in the actual list of substances enumerated. Except blood-letting, a great part of the remedies classed under this division consist rather in the removal of the ordinary stimuli, as heat, light, and the accustomed articles of diet, than in the exhibition of any powerful means of cure, while many of the substances which are generally considered as diminishing the action of the vital powers are distributed among the other classes, according to their supposed effect on some of the functions.

A new arrangement of the materia medica has been lately proposed by Dr. Young, which, although not without some objections, bears many marks of the well-known learning and talents of the author. He divides all remedies into four classes,—mechanical agents, chemical agents, vital agents, and insensible agents. The mechanical agents are arranged under the four heads of climates, habits, clothing, and instruments and operations. In the second class there are five orders—caustics, antiseptics, antidotes, demulcents, and diluents; the general objects of which are sufficiently expressed in their respective titles. The vital agents are divided into such as support strength, including only the nutrients, those which cause action, and those which diminish it. The remedies which cause action are subdivided into those which produce only a partial and temporary effect, and those which produce a permanent increase of power. Under the first of these subdivisions there are seventeen orders, arranged, for the most part, according to the organ on which they act, but partly, also, according to the degree or nature of the operation. They are as follow: 1. Expergefacients, those remedies which generally increase the activity of the nervous system; 2. Excitants, those which produce a strong local impression upon the nerves; 3. Calefacients, those which increase the action of the heart; 4. Sudorifics, those which promote the secretion from the skin; 5, 6, 7. Errhines, Sialogogues, and Expectorants, such substances as promote the secretion from the nose, the salivary and bronchial glands, respectively; 8. Stomachics, those remedies which promote the secretion of the gastric fluid, or improve its quality; 10, 11, 12, 13. Cathartics, Carminatives, Diuretics, and Emmenagogues, those substances which promote the expulsion of fæces, of flatulence, of urine, and of the menstrual discharge, respectively; 14. Epispastics, substances which promote a serous secretion under the cuticle; 15. Suppuratories, those which promote or modify suppuration; 16. Sorbefacients, those which promote absorption; and 17. Astringents, those which increase tonic contraction.

The remedies which are supposed to produce a permanent increase of action and of power are all included in one class, under the name of tonics. The remedies which diminish the powers of action and of sensation are subdivided into such as do this primarily, and those which do it secondarily: the first including narcotics, those which cause sleep; sedatives, those which ease pain; nauseants, those which prove debilitating by their immediate action on the stomach; and diaphoretics, such as are supposed to produce perspiration, rather by relaxing the exhalents than by increasing the force of the circulation, a distinction which the author admits is almost superfluous. The remedies which diminish action secondarily, are the exhaurients; and under the third great division of insensible agents we have only one class, the specifics.

We have no hesitation in preferring the arrangement of Dr. Young to any which has been previously proposed: it is more comprehensive—is founded upon more correct principles, bearing a more accurate relation to the actual condition of the animal economy, and is less involved in hypothesis and speculation. But, as we have already observed, we do not think it without objections, and these we shall now proceed to state. With respect to his primary division of all medical agents into mechanical, chemical, vital, and insensible, we conceive the three first to be correct; but with respect to the fourth, which is intended to include the specifics alone, we think there is an obvious inaccuracy, both in the separation of these into a distinct class, and in the name which is imposed upon them. They consist merely of such remedies as produce a decided effect in the cure of certain diseases, but where we are not able to explain the mode of their operation; they, therefore, possess no common property, except that of their specific difference, and, consequently, they have no claim to be classed together, unless what is derived from our ignorance. It would have been more proper to have placed them in an appendix, as what at present do not admit of classification, than to give them an appearance of classification which at present they do not really possess.

The mechanical agents compose a very important division, comprising many of those remedies which were formerly included under the whimsical and absurd title of non-naturals; but we do not think that their present appellation is peculiarly appropriate, while it appears to us that the division might have been extended with advantage, and that, perhaps, it would have been better if the articles which it contains had been arranged under a greater number of heads. We have already remarked, upon what appears to us the inaccuracy of including dietetics, and the substances which compose the materia alimentaria, under the same department with the materia medica. We think they ought to be subjects of distinct consideration, as there is an obvious and natural difference between those means which we employ to support life, and those which are only useful in restoring the deranged actions of the system.

The division into chemical and vital agents is correct, although, in many instances, it may be difficult to determine into which class certain substances ought to be placed; and there are likewise cases in which the remedies act in both these ways, according to the manner in which they are used, or the parts to which they are applied. But, in this case, it is necessary to follow the method which Dr. Young has adopted, of placing the substances under two or more classes, with a reference from the one to the other. The very first article in his list of caustics, the first chemical class, namely, the nitrate of silver, operates certainly as a vital agent when it cures epilepsy; and with respect to the second, arsenic, the author himself acknowledges that it is perhaps "rather a vital agent, even when applied as a caustic." It may be justly questioned, wheter there be any substance to which the title of antiseptic should be applied, as entering into the list of medicinal agents: if there be any, they can only be such as act topically, when applied to the surface of parts; and under this restriction we conceive that carbonic acid might properly have had a place among the substances which obviate putrefaction. The antidotes are defined, those remedies which are "calculated to neutralize offending substances," and consist exclusively of the different alkaline bodies. We think it might be shewn, that there are other states of the body, except those that depend upon an excess of acid, which would come under the description of Dr. Young's antidotes; if, however, this should not be the case, we should prefer the name antacid, as being more directly significant of their object, and as avoiding a word, to which an essentially different meaning had been formerly attached.

There is some obscurity about the action of demulcents; we must reject much of the old doctrine that was maintained upon the subject, and, at least when applied internally, we can conceive of no effect which they can produce, except merely as substances of a certain mechanical consistence, actually covering the parts to which they are applied. Passing by the diluents, which are all properly referred to the one article of water, and the nutrients, which, as we have already observed, seem scarcely entitled to the appellation of remedies, we next come to the great division of the vital agents, or those which cause action, necessarily including the greatest part of the most active articles of the materia medica.

We have already given a sketch of the manner in which this great class is subdivided; in many respects we coincide with the ideas of the author; and we are aware that no arrangement can be proposed, against which some objections might not be raised. We conceive that Dr. Young has fallen into an error, in paying too much regard to the nervous system, and too little to the sanguiferous. Regarding the latter as the grand and primary agent in the animal economy, we should be inclined to search for those substances which act in the first instance through its medium, and should have placed these in the first class; or if there be some which can be clearly denoted as possessing this power, we should have preferred beginning with those which act upon the whole body generally, and should have given to these the old expressive title of stimulants. It may be objected to the term calefacients, that it is derived from one effect only of the substances included under it, and is not expressive of the general mode of their operation. We shall pass over the next classes, which correspond to what are usually called the evacuants, only pointing out the manner in which the cathartics are arranged under the heads of cholagogues, hydragogues, simple propellents, and anthelmintics, an arrangement which perhaps savours a little of false refinement; nor have we any thing particular to observe concerning the epispastics, and the suppuratories. With respect to the sorbefacients there is some obscurity; it is doubtful whether there be any article which possesses the specific property of acting exclusively and primarily upon the absorbents; but if we are to admit the existence of such a class of substances, we confess that the list presented to us by Dr. Young appears extremely scanty. The only internal remedies are muriate of ammonia, burnt sponge, and taraxacum: the first, a body of very uncertain effect; the 2d, probably nothing more than an awkward form of administering the volatile alkali; the 3d, acting as a diuretic, and on the same principle with others of the same class. The last of these subdivisions, the astringents, is also one of doubtful operation, and concerning which it may reasonably be questioned, whether the action of some of the articles included in it is more chemical or vital. Most of the substances act as mechanical astringents on dead animal matter; and we conceive that there is no inconsistency in extending their operation to the living body, where they are applied to its surface, and especially to the termination of the exhalent or secretory vessels. The class of tonics, the only agents which are conceived to possess the property of producing a permanent increase of action and of power, seems to us to be very miscellaneous, and to include a variety of articles, which cannot be conceived to act upon the same principle, although they may seem in some degree to produce a similar effect. We particularly refer to the vegetable and metallic substances which compose this class in about an equal proportion. Although bark and steel, or cusparia and arsenic, may be properly given in combination, and may tend, by their united effect, to remove a certain morbid condition of the body, yet it does not follow that they operate either on the same organ, or by means of the same function.

There is no part of the materia medica which has given rise to more controversy, than the existence and arrangement of those substances which have been usually styled sedatives, those which "diminish the power of action and of sensation." Although there can be no reasonable doubt of the existence of bodies, the primary operation of which is sedative, yet it is often difficult to discriminate between these, and such as diminish power and sensation by their secondary effect alone; for we have clear evidence, that this kind of diminished action may be produced by a certain management of those substances, which, in the first instance, are decidedly stimulant. Dr. Young has, we think, made a correct distinction between narcotics and sedatives, although we should rather doubt the propriety of the definitions which he has given of them, as in the first case causing sleep, and in the other easing pain. His nauseants and his diaphoretics are confessedly sedative, only in consequence of their previous operation on the stomach and the skin. With respect to the first of them, we may perhaps allow the justness of the observation; but the second we think hypothetical and superfluous, as indeed the author himself intimates. At all events, there is an obvious inaccuracy in this part of the arrangement, in not placing these classes under the subdivision of those which diminish action secondarily. We have already offered our objections against the class of insensible agents, both with respect to its principle and its denomination. The number of articles that are thus arranged is not considerable, and the author has prudently prefixed to the greatest part of them a note of interrogation. It would be curious to compare the lists of specifics which have been at different times announced by the writers on the materia medica. In proportion to the increasing knowledge of the successive generations of physicians, this list has uniformly diminished; and we may, with some confidence, estimate the state of medical information in any age or period by referring to this circumstance.

After this examination of the different methods that have been adopted in the classification of remedies, we shall proceed to make some general observations upon their mode of operation and their uses. In doing this, we shall take the system of Dr. Young as the basis of our arrangement, proposing, however, certain alterations in it, according to the ideas which we have already suggested. Were we to consider the subject in its widest extent, we might divide the objects of acology into those that act upon the body generally, and those that act upon particular organs, or through the medium of particular functions only. The first of these divisions nearly coincides with the non-naturals of former writers, and the mechanical agents of Dr. Young, while the latter belongs more immediately to pharmacology. The term *mechanical agents* we conceive to be obviously incorrect. It is difficult to conceive on what principle climates and habits can be considered as acting mechanically; and although we should allow this word to be more applicable to cloathing, yet its effects can scarcely be referred to a mechanical cause. Under the head of general agents, we shall include air, temperature, soil and situation, diet, exercise, occupations and modes of life, habits, both moral and physical, cloathing, sleep, and the passions. But although these may all of them be occasionally employed in the cure of disease, and are therefore entitled to the appellation of remedies, as they do not form articles of the materia medica, they cannot be treated of in this place. We shall take an opportunity of considering them under the article MEDICINE, where they will more naturally fall under our notice, either as constituting the causes of disease, or as operating in the preservation of health.

We shall now therefore proceed to the second part of acology, that which treats of those remedies that act upon particular organs or functions, consisting for the most part of substances either applied to the surface of the body, or received into the stomach, for the purpose of producing some particular effect upon the part, or of fulfilling some indication necessary to counteract a certain morbid action. To this department, the term *pharmacology*, or *materia medica*, has been more exclusively given, because the greatest part of the agents employed are such as are used only in the practice of medicine.

Before we attempt to arrange the articles of pharmacology, there are two preliminary points to be attended to. In the first place, it must be remarked, that although there are certain bodies, the action of which is directed to one particular object, yet we perceive that they are frequently not confined to this single effect. It happens, in some cases, that one change in the system necessarily induces other changes; while there are also cases, in which, when a particular operation has advanced to a certain degree, it becomes incapable of proceeding any farther, although the same cause may remain applied, so that perhaps some state ensues even the reverse of the one first induced. We may remark, secondly, that there is frequently a gradation of effect from one substance to another, until we arrive at length at a body, which may be considered as possessing an intermediate state; so that it is impossible to determine with accuracy in which division it ought to be incluted. It will therefore be necessary, in distributing the various medicinal substances into their respective classes, to place at the head of each list those bodies that possess the most decisive operation, and to subjoin, in succession, those that are of a more mixed or ambiguous nature. After all, it must necessarily happen, that some substances will require to be placed in two or more classes, both because they may actually produce more than one primary effect, or because their secondary effect may be equally or more important than that which they exercise in the first instance.

We shall begin by arranging the subjects of pharmacology into two great divisions: 1. The mechanical and chemical agents; and 2. The vital agents. Under the title of mechanical and chemical agents, we propose to include those subtances which operate upon the part of the body to which they are applied, merely by their physical properties, without exciting any action in the vital powers of the body itself. Of these we shall make five classes: 1st, Caustics; 2d, Astringents; 3d, Antiseptics; 4th, Antacids; and 5th, Demulcents. To the four first of these the definition applies with tolerable correctness; the operation of the last is more doubtful, but it appears to be in a great degree mechanical, and to be but little concerned with the specific properties of vitality.

The vital agents are first arranged under three subdivisions: 1st, Those which increase action; 2d, Those which diminish action; and 3d, Those which increase strength. The first of these subdivisions, those which increase action, are arranged under 14 classes, depending principally upon the part on which they act. They are as follows: 1st, Excitants, those agents which increase action generally; 2d, Stimulants, those which increase the action of the heart and arteries; 3d, Expergefacients, those which increase the action of the nervous system; 4th, Sorbefacients, those which increase the action of the absorbent system; 5th, Sudorifics, those which increase the action of the cutaneous vessels; 6th, Errhines, those which increase the discharge from the nostrils; 7th, Sialogogues, those which increase the secretion of saliva; 8th, Expectorants, those which increase the secretion from the bronchial glands; 9th, Emetics, those which increase the action of the stomach; 10th, Cathartics, those which increase the action of the intestines; 11th, Cholagogues, those which increase the action of the liver; 12th, Carminatives, those which promote the discharge of flatulence; 13th, Diuretics, those which increase the secretion of urine; and 14th, Emmenagogues, those which promote the discharge of the menses. In the 2d division of vital agents, those which diminish action, there are three classes; 1st, Sedatives, those agents which diminish action generally; 2d, Narcotics, those which promote sleep; and 3d, Antispasmodics, those which remove irregular action. In the 3d division of vital agents, those which increase strength, we have only two classes; 1st, Stomachics, those which promote digestion; and 2d, Tonics, those which increase the contractile force of the muscular fibre. The following table will present a synoptical view of the whole arrangement.

Acology is divided into the doctrine of

1. General Remedies.
2. Particular Remedies, *or* Pharmacology.

A. General Remedies.

1. Air.
2. Temperature.
3. Soil and situation.
4. Diet.
5. Exercise.
6. Occupations and modes of life.
7. Habits.
8. Cloathing.
9. Sleep.
10. Passions.

B. Particular Remedies.

a. *Mechanical and Chemical agents.*
b. *Vital agents.*

a. *Mechanical and Chemical agents.*

1. Caustics.
2. Astringents.
3. Antiseptics.
4. Antacids.
5. Demulcents.
    Diluents.
    Emollients.

b. *Vital agents.*

aa. Causing action.
bb. Diminishing action.
cc. Increasing strength.

aa. *Vital agents causing action.*

1. Excitants, increasing action generally.
2. Stimulants, acting on the sanguiferous system.
    Vesicants.
    Rubefacients.
3. Expergefacients, on the nervous system.
4. Sorbefacients, on the absorbent system.
    Evacuants.
5. Sudorifics, from the skin.
6. Errhines, from the nose.
7. Sialogogues, from the mouth.
8. Expectorants, from the bronchial glands.
9. Emetics, from the stomach.
10. Cathartics, from the bowels.
11. Carminatives, expelling flatus.
12. Cholagogues, evacuating bile.
13. Diuretics, increasing the urine.
14. Emmenagogues, promoting the menses.

bb. *Vital agents diminishing action.*

1. Sedatives, diminishing action.
2. Narcotics, promoting sleep.
3. Antispasmodics, removing irregular action.

cc. *Vital agents increasing strength.*

1. Stomachics, promoting digestion.
2. Tonics, encreasing the tone of the muscles.
    Specifics.

We shall now proceed to make a few observations upon each of the several classes, and shall enumerate some of the most important remedies that belong to them. With respect to the caustics, we have little to remark as to their mode of action. In the first instance, it is entirely chemical, or consists in the attraction between the animal body and the substance employed, exactly similar to what takes place when a similar substance is applied to a portion of the same animal matter taken from the dead subject. This may be regarded as the effect of the most simple kind of caustics; but there is another species of them, where the destruction of the animal matter seems to be a secondary kind of operation, or at least where it is accompanied by a degree of vital action, somewhat resembling inflammation, which appears to be necessary to the subsequent disorganization of the part. This difference of action will give rise to a division of the class of caustics into two species, the simple caustics, and the inflammatory caustics; a variety, the existence of which seems sufficiently evident, although it may not be easy, in some cases, to determine in which division each particular article should be placed; but we have little hesitation in referring caustic potash to the first, and arsenic to the latter. The principal caustics that are employed in medicine are potassa, calx, and the combination of the two, the potassa cum calce, which constitute the simple caustics; of the inflammatory caustics, beginning with the milder, and proceeding to those that are the most violent, we may enumerate ærugo, cupri sulphas, some of the more active mercurial preparations, argenti nitras, antimonii murias, and arsenici oxidum.

The action of the astringents is more obscure, and has been the subject of much controversy among pathologists. This, we think, has partly arisen from these substances not having been sufficiently discriminated from some other articles of the materia medica, especially from the tonics, and partly from the circumstance, that there are probably but few substances which possess the simple property of astringency, or which do not produce some other effect in conjunction with it. We should define astringency to be that property, which certain substances possess, of bringing the particles of the body to which they are applied into closer contact, without, in other respects, affecting its mechanical structure. This effect is well known to be produced, by various substances, upon dead animal matter; and we conceive that many of the same agents will produce it upon living animal matter. In many cases it is obviously caused by the presence of the tanning principle, and it may be conjectured that the part of the body on which the tan acts, is the membranous matter, under some of its various forms or structures; but this, it is admitted, is a question concerning which we have no decisive evidence. On this principle, we may conceive that astringents act both internally and externally, although it is probable that it is in the latter case only that they operate by their simple astringency. When they are applied to the mucous membrane which lines the mouth, the stomach, and the various parts of the alimentary canal, even if we admit that their first effect be to bring the constituents of the membrane into closer contact, yet it is impossible that this object can be accomplished, without other effects being produced; the secretions of the mucous glands will almost necessarily be restrained, the motion of the muscular fibres will probably be diminished, and the sensibility of the nerves likewise impaired. We make the same kind of subdivision of the astringents, that we did of the caustics, into those that act by simple astringency, and those which, together with their astringency, act upon the vital powers of the system. Among the simple astringents we may enumerate the various vegetable substances, into the composition of which tan enters in any considerable quantity; in this division we place galla, quercus, catechu, kino, granatum, hæmatoxylum, and rhatania. We may then place those substances, of which astringency appears to be the principal operation, but which do not contain tan, and which likewise possess some other property, connected with their astringent action; of this kind are the acids, when either naturally weak, as vinegar, and the other vegetable acids, or the mineral acids, when sufficiently diluted, some of the neutral salts, which perhaps always act by their containing an excess of acid, as alum and certain metallic salts, of which the acetate or superacetate of lead is the chief, which perhaps produces its effect more by diminishing the sensibility of the nervous system, than by its chemical or mechanical action on the part. We exclude from the list of astringents all those substances which seem rather to belong to the stomachics and the tonics, such as have little or no effect, except when received into the stomach, and, together with their supposed astringency, either promote the powers of digestion, or increase the tone of the muscular fibre. Under certain circumstances, one of the most powerful and direct of the astringents is cold, the action of which is probably, in part at least, mechanical, although at the same time it no doubt affects the vital functions.

The next class, the antiseptics, derive their denomination from their efficacy in resisting putrefaction, an operation which is strictly chemical, and is daily employed in the preservation of dead animal matter. In our list of antiseptics, we shall only include those substances which act immediately upon the parts to which they are applied; for, with respect to those which have been supposed to produce some change in the system at large, by which its constituents are prevented from running into a state of putrescence or decomposition, to which, in certain diseases, it is supposed to have a tendency, we may observe, that the whole doctrine is hypothetical, and that even were we to admit its correctness, and conceive the operation of the remedies to be antiputrescent, yet the primary effect, in these cases, is of a different nature, and is very various, being, according to circumstances, at one time tonic, at another stimulant, and at another sedative. We shall not, therefore, include cinchona among the antiseptics; because if it produce any effect of this kind, it is by means of its tonic power, exercised on the system generally; nor various articles which seem to prevent decomposition by their astringency, nor others, such as some of the aromatics and resins, which have been called antiseptic, but the effect of which seems to be rather to correct the fœtor of the putrid parts, than actually to prevent their decomposition. After these restrictions, the only substances which can be strictly entitled to be considered as simple antiseptics, are carbo ligni, acidum carbonicum, cerevisiæ fermentum, dauci cataplasma, which two last articles owe their efficacy solely to the carbonic acid which they evolve, acetum, and alcohol dilutum.

Antacids are a class of substances, the effect of which is to neutralise the acid which, under certain circumstances, is generated in the stomach, and is both the cause and the effect of an imperfect state of the digestion. They consist either of the alkalies or alkaline earths, and their primary effect is entirely chemical. The antacids employed in medicine are different forms of the three alkalies, potash, soda, and ammonia, generally in the state of carbonate or subcarbonate, magnesia, either pure or combined with carbonic acid, and the carbonate of lime. There are some other substances of a very different nature, which have been included under this class, as counteracting the acid of the stomach; but they are to be regarded as preventing the formation of acid by producing some change in the digestive organs, and are therefore to be referred to the class of tonics or stomachics, according to the nature of their primary operation. With respect to an acid state of the fluids generally, its existence is at least very doubtful; and if it were present, it would probably be impossible to counteract it by the direct operation of any chemical remedies.

The last class of chemical or mechanical agents is the demulcents, under which we propose to include what have been called the diluents and emollients. We shall define this class to be those substances which envelop acrid matter, cover the surfaces that are too sensible to external impressions, and soften hard or dry parts. We regard their operation as, in the first instance, purely mechanical, and that all the effect which they produce on the system at large depends upon their power of relieving irritation, by removing or obviating the irritating cause. The operation of demulcents depending entirely upon their consistence, or their physical properties of cohesion, we must be directed in our choice of them entirely by the facility with which they can be applied to the different organs. For the internal part of the mouth, and to the fauces, we use mucilages and syrups, while to the skin we apply ointments or liniments of various kinds. Under the head of demulcents we have included emollients; because, although the operation of the two may not be precisely similar, yet they are generally so connected together, that one effect almost necessarily produces a certain degree of the other. The same remarks apply also to what have been styled diluents, which may all be referred to water, the only substance that can properly be considered as diluting, but which likewise possesses both a demulcent and an emollient quality. We may farther remark, that water necessarily forms the basis of a large part of the proper demulcents, all those of a mucilaginous nature; their mechanical effect necessarily depends upon their consistence, and is always regulated by the proportion of water to which they are united. But although we speak of the primary action of water as purely mechanical, it may be a fair subject of discussion, whether it does not possess a secondary operation, of a more complicated and less obvious kind; whether it be not capable of being carried by the absorbents into the system; of being united, in a greater or less proportion, to the circulating fluids, increasing the general bulk of the body, and affecting the consistence of the secretions and excretions. This opinion has been commonly maintained, and seems to be supported by plausible arguments; still, however, in a certain sense, the action may be considered as mechanical, or at least to be of that indeterminate kind, which may be regarded, with almost equal propriety, as belonging either to a physical or a vital operation. The pharmaceutical articles which we shall include in this class are, aqua, acaciæ, gummi, tragacantha, althæa, cydonia, lichen, and various other mucilages; amylum, avena, and other grains employed in the form of decoctions, glycyrrhiza, amygdalum, saccharum, various fruits which consist principally of mucilage and sugar, mel, adeps, sevum, cera, cetaceum, and olivæ oleum. To these we may add, as one of the most powerful agents, the vapour or steam of water, as applied to the surface of the body, and warm water itself, either received into the stomach, or employed in the form of the warm bath.

We now come to the second division of the objects of pharmacology, those which we have called vital agents, because the primary effect which they produce upon the body consists in some affection of its appropriate powers, contractility and sensibility, and consequently depends upon an action which cannot take place except during life. The operation of the vital agents is necessarily more complicated, and frequently more obscure, than that of those which we have already examined, in proportion to the greater difficulty which we have in comprehending the nature of vital action in general, and especially in ascertaining the immediate change which is produced in the part to which the substance is applied. Although the two functions of contractility and sensibility are essentially distinct, both in their seat and in their effects, yet they are generally connected together, and it is not easy, in many cases, to distinguish how much of any action is to be referred to one or the other of them, or which is to be regarded as the primary operation, either as to the order of time or the degree of effect. It may be doubted, whether there be any substance which can act equally upon both of them; while, on the contrary, it is equally uncertain, whether there be any substance that affects either of them individually, without likewise exciting an action in the other. All that we can do is to be guided by the most correct observation of the phenomena, being fully aware of the difficulty of the subject, and remembering, that, although we may be induced to attempt a classification, we have the means of accomplishing it only in a very imperfect manner.

The first class of vital agents we have called excitants, by which we understand those which simply increase action, without regarding the nature of the effect, or the organ on which they operate. By the term "causing or increasing action," we mean to express generally, the production or increase of those primary functions, which are essential to the existence of life. An augmentation of force or velocity in the pulsations of the arterial system, an increase of muscular power, either as indicated by the motion of the limbs, or by the functions which are immediately derived from the contractility of the muscular fibre, are effects, either generally or separately, which are all to be regarded as falling under this description. To those substances which seem to affect all parts of the system in an equal degree, whatever may be actually the case, we apply the name of excitants, and under this denomination we shall place the different preparations of alcohol, wine, æther, the combinations of æther and alcohol, perhaps camphor, the more acrid essential oils, and the most stimulating aromatics, such as capsicum, sinapis, and zingiber. To these we may add the operation of the electric fluid, whether applied in the form of common electricity or of galvanism.

Our next class is that of the stimulants; a title which we propose to restrict to those agents, the primary action of which seems to be on the sanguiferous system, when we observe the pulse to be affected, both as to its force and velocity, but when we observe only a slight and secondary effect to be produced on the nerves. Although we conceive that there is an actual foundation for the distinction which we make between the excitants and the stimulants, yet we are aware of the great difficulty of discriminating between them in many particular cases; and it not unfrequently happens, that the same substance, according to the quantity in which it is employed, may act either as an excitant or a stimulant. This we consider to be particularly the case with vinous fluids of all descriptions, which in small quantity we should rank among the stimulants, but which, when used copiously, afford a most decisive example of the operation of the excitants. Taking into account all these various considerations, we should propose the following list of stimulants; many of what have been called the warm gums and resins, as galbanum; some of the less irritating of the aromatics, cinamomum, cardamonum, and myristica; guaiacum, mezereum, terebinthinæ oleum, small doses of many of the excitants, external warmth applied in various ways, and especially under the form of the warm bath. To this list we shall be disposed to add hydrargyrus, although, as we shall afterwards have occasion to observe, its operation is not that of a simple stimulant.

Besides the articles which we have enumerated, and which exercise a general stimulating power, there are others which obviously act on the sanguiferous system, but which are only of partial application; among these we may rank what have been styled the vesicants and the rubefacients, to which may be added the suppuratories, if there be any articles to which this denomination can be correctly applied. The operation of the vesicants is strictly local, and appears to depend upon a powerful stimulating effect on the serous vessels that are connected with the skin, while we may consider the rubefacients as exercising an action, which is somewhat more extensive, but less violent, so as to produce less effect upon the cutaneous vessels, but to extend farther into the minute arteries of the contiguous parts. Among the vesicants and the rubefacients we may place lytta, sinapis, antimonium tartarizatum, ranunculus, ammonia, terebinthinæ oleum, most of the caustics, when only in small quantity, and many of the excitants and stimulants, when applied externally. One of the most powerful of the rubefacients is the local application of heat, especially under the form of fomentations.

Expergefacients are the next class of substances that cause action, and are defined to be those that operate principally upon the nerves, or at least where the action upon the nervous system is proportionally more apparent than that upon the heart and arteries. The same difficulty, in some degree, occurs here as on the former occasion, in distinguishing between the excitants and the stimulants, that although there is sufficient grounds for admitting of an essential difference between the classes, yet there are many particular cases in which it is very doubtful to which division certain articles should be referred. We may frequently be guided in our decision, by inquiring, whether the substance in question possess any property, which acts powerfully and directly upon the organs of sense, especially upon the taste or smell, for in this way a primary impression is received upon the nerves of the mouth and nose, that operates independent of any effect that is produced through the medium of the stomach. In the class of expergefacients we may place assafœtida, and the fetid gums generally, castoreum, valeriana, moschus, various essential oils, as those of lavender and peppermint, allium, absinthium, ruta, and some other fetid vegetables. To this class we are to refer a greater variety of agents of very doubtful authority and uncertain effect, which by some practitioners have been regarded as the most active medicines, and by others as perfectly inert. This circumstance depends upon their operation being through the medium of the nervous system, and consequently involving a change, not only in the physical structure of the body, but in the sensations, by which the mental faculties in general, and the imagination in particular, are liable to be affected. Hence many of the histories that we have of the wonderful effect of remedies are literally true, at the same time that the medicine itself may be perfectly inefficacious; but the farther consideration of the effect of the imagination in the cure of diseases must be referred to the article Medicine.

Our fourth class is that of the sorbefacients, the agents which increase the action of the absorbents. The idea of this kind of action is in itself sufficiently intelligible and definite, so that we do not hesitate to make it the foundation of a separate division, yet there is a considerable difficulty in ascertaining what articles should be arranged under it. We are indeed acquainted with various means of producing an increase of absorption, but in most cases it may be conjectured, that the effect is only secondary or consequential. Cathartics and diuretics are both of them frequently employed to remove serous effusion, and we have abundant evidence of their efficacy in this respect; but there is reason to suspect that their operation is, in the first instance, upon the secretory vessels, and that the subsequent absorption depends either upon a general increase of activity in all parts of the system, or that it is owing to some connexion between the two operations, by which, wherever the former is augmented, the latter necessarily becomes so likewise. Exercise, either general or partial, promotes absorption; but it may be questioned, whether it operates in any other way than by first exciting the arterial system, and, through this medium, that of all the parts that are connected with it. In the same manner, some of the astringents tend to carry off collections of fluid from the cavities of the body, and thus appear to promote absorption; but here it may be doubted, whether the operation be not essentially of a different kind, and whether the real effect be not rather upon the secretory vessels, in preventing their action, and, by thus cutting off the supply of matter, virtually diminishing the accumulation.

Another set of remedies, which have been supposed to promote absorption, are those which we shall afterwards have to consider under the title of tonics, and to these we may attribute a certain degree of efficacy; but we conceive that it depends not upon an increase of action in the absorbents specifically, but upon an increase of strength in the system generally, of which this particular set of vessels only enjoy their due proportion. A remark somewhat analogous to this applies to the agent, which has been conceived to possess the most decisive sorbefacient power, mercury; but here, again, it may be doubted, whether it affects the absorbents more than all the other parts of the body which possess contractility. Perhaps one of the most unequivocal agents in producing absorption is pressure, when long continued, and not too powerful; but here we may offer a plausible explanation of the fact, without conceiving of any specific increase of action in the absorbent vessels. It generally happens, that the absorbents lie deeper or farther from the surface than the arteries, or the secretory vessels connected with them; and it may therefore be supposed.

that when pressure is employed, the supply of the materials is cut off, while, at the same time, absorption proceeds at its usual rate. But, after making allowance for these circumstances, still, as a matter of fact, we know that there are various agents which promote absorption, and that, in some instances, it is at least doubtful, whether there be any primary operation which can be designated as its direct cause. These agents, in the present state of our knowledge, we are entitled to class as sorbefacients; and we shall propose the following list:—Hydrargyrus, under a variety of forms, but more especially under that of ointment; emetics, particularly when given in nauseating doses; small quantities of most of the purgatives, where we may frequently observe an absorbent effect to be produced, which seems not to be merely the consequence of their previous evacuation; cold, when applied in such a manner as to be succeeded by moderate reaction, exercise, friction, and pressure.

We have now considered the four first classes of agents which increase action, beginning with those that produce these effects on all parts of the body, and afterwards taking in succession those which act upon the three great systems of the blood-vessels, the nerves, and the absorbents respectively. We now come to those substances that act only upon separate organs. Their effect being to increase the natural operation of these organs, is for the most part evacuant, and there is found to be a clear relation subsisting between them, so that it frequently happens that we are able, by particular management, to substitute them for each other; an article, which, in a certain dose, produces cutaneous perspiration, in larger quantity will prove emetic, and in a still greater dose will act as a purgative. Some facts of this description seem to have influenced the mind of Brown in the formation of his hypothesis, to have led him peremptorily to reject all specific action, and to conceive, that the operation of all remedies might be reduced to a mere scale of quantity. But the most ample experience demonstrates the fallacy of this opinion; while the pertinacity with which the doctrine was maintained forms one of the most remarkable examples of the force of prejudice, and the power which a plausible theory obtains over the mind, in contradiction to the less captivating effects of a minute and patient observation of morbid phenomena.

The first class of the evacuants are the sudorifics, those agents which increase the cutaneous perspiration. Under this title we propose also to include the diaphoretics, which may be considered as differing from the sudorifics merely in the degree of their operation. That there are certain substances which, as far as we are able to observe, have the immediate effect of exciting the action of the cutaneous vessels, seems obvious; yet it is not easy to determine in what manner the operation is conducted. We can scarcely imagine that the substances in question are received into the circulation and carried to the part, so as to act directly either upon the vessels or the nerves that belong to it; and indeed there are certain cases, in which the cutaneous perspiration is the most copiously produced, where no medicinal substance has been actually received into the stomach. The most plausible supposition, however, is, that perspiration is caused in all cases by a certain relation in the different parts of the arterial system to each other, by the reaction of the capillaries after they have been in a state of complete atony, or while their action remains unaltered, yet that of the heart and larger arteries has been unusually excited. The application of external warmth, of warm fluids taken into the stomach, the transient application of cold to the surface, those internal changes in the circulation which terminate in febrile paroxysms, as well as other methods of exciting perspiration, which at first view seem anomalous and difficult to reconcile to any general principle, may, we apprehend, be all explained on the above supposition. Among the most active sudorifics, we may enumerate warm drinks; external warmth, more especially the warm bath and fomentations; moderate doses of many of the excitants and stimulants; antimonial preparations; ipecacuanha, and especially the pulvis ipecacuanhæ compositus; nauseating doses of the emetics generally; guaiacum; liquor ammoniæ acetatis; citrate of ammonia; sarsaparilla; and spiritus ætheris nitrici.

The two next classes, the errhines and the sialogogues, act immediately on the part to which they are applied; in the former case, to the mucous membrane of the nostrils, and in the latter to that of the mouth and fauces; and it is probable that their operation is strictly stimulating to the glands with which this membrane is furnished, and which serve for the secretion of mucus. The most powerful errhines are asarum and tabacum, and of the simple sialogogues, pyrethrum. We do not place mercury in this class, because, according to the remark which has been made above, although one of its most obvious effects be to excite the salivary glands, yet it is equally obvious, that this is a secondary effect, and consequential to its operation on the system at large.

The class of expectorants, those agents which increase the secretion of the bronchial glands, is nearly related to that of the two last, yet it differs from them, inasmuch as the substance is less directly applied to the part. There is, indeed, some difficulty in explaining the way in which these medicines operate, unless we should conceive it probable that the membrane lining the trachea, being continuous with that of the fauces and œsophagus, may experience the effect of any agent which is applied to the latter, and have a similar action propagated along its surface. But of the action of certain substances as promoting expectoration there can be no doubt, and the following may be regarded as among the most powerful:—antimonium, ipecacuanha, scilla, senega, ammoniacum, the vapour of warm water, and perhaps that of æther.

We have placed emetics among the evacuants, because their primary effect is to discharge the contents of the stomach; because they seem to affect the mucous membrane of this organ in the same manner with other substances that are applied to a similar structure; and because there seems to be an evident relation between the operation of these and the other evacuants, as indicated by the power which they possess of producing a different effect, according to the quantity in which they are employed. Yet in one important particular the emetics are unlike all the rest; for, while the others promote or increase the natural action of the part, these absolutely invert it. Perhaps, however, what appears at first view a contradiction, may be reconciled to the general principle by a little farther consideration. The actions of the stomach would seem to be so arranged, and its powers so adapted to the object of nutrition, that it possesses not merely the ordinary function of carrying forward its contents in a regular direction, but when, either from the bulk or the nature of the contents received into it, there is any great difficulty in accomplishing the task, it has the faculty of rejecting the offending matter in a more prompt manner. This is so effected, by a peculiar arrangement of its parts, or by the relation which they bear to each other, that when it has passed beyond the limits of its greatest natural action, it necessarily falls into the state where its action is inverted. Thus a plentiful supply of food promotes the discharge of the stomach by the intestines, while an excessive quantity causes vomiting; and a small dose of an emetic proves purgative, while a large dose of a purgative causes vomiting. The most active emetics employed in medicine are antimonium tartarizatum, cupri sulphas, zinci sulphas, ipecacuanha, sinapis, and anthemis.

The cathartics are the last class of the evacuants that act upon the mucous membrane; a very numerous and powerful set of agents, the operation of which is upon the part to which they are applied, and seems most direct and obvious, yet, from the multifarious nature of the substances which compose the list, we are almost necessarily led to conclude that they do not all act upon the same principle. Proceeding upon their physical and chemical properties, we may arrange the cathartics under the three divisions of oleaginous and saccharine substances, vegetable resins and extracts, neutral and metallic salts. Although we are not able to form a classification of effects, which will entirely correspond with the physical properties of the substances employed; yet, to a certain extent, something of this nature may be accomplished, at least there are three kinds of purgative operations which may be distinctly characterized. The first of these divisions seems simply to discharge the contents of the bowels; the second, without much affecting its nature, appears considerably to increase the quantity of matter discharged; they often produce griping, and although not very rapid in their operation, are ultimately powerful; while the third class produces a speedy discharge of matter of a watery consistence. Different appellations have been given to the cathartics, partly corresponding with this variation in their effect, and although the titles are not always strictly applicable, yet we may use the following, as affording some indication of their respective powers. In the first division, under the denomination of laxatives, we may place oleum olivæ, oleum ricini, saccharum, manna, mel, large quantities of aqueous fluids taken into the stomach, or used in the way of injections, many of the mucilaginous fruits, some partaking of an acid, and others of a saccharine nature, as tamarindus and carica; and, although differing from them in their chemical nature, we may place in the list of laxatives, magnesia, either pure or carbonated, and sulphur.

To the second class of cathartics, which may be styled drastics, we refer the substances which appear actually to augment the quantity of fœcal matter, including most of the vegetable extracts and resins, aloes, jalapa, colocynthis, scammonea, senna, terebinthina, rheum, and some others of less efficacy. Under the denomination of hydragogues, those which produce watery evacuations, we may class the neutral and subacid salts; sodæ sulphas, soda tartarizata, sodæ phosphas, potassæ supertartras. To this class we must also refer some vegetable substances, especially elaterium, cambogia, helleborus niger, and veratrum; and likewise some metallic preparations, of which the most important is calomel.

Next to the cathartics we place the carminatives, those agents which produce the discharge of flatulence from the alimentary canal. These both act upon the same organ, yet they produce a very different effect, and probably operate upon a different principle: it may be conjectured, that while the former affect the glands, and perhaps the muscular fibres of the intestines, the latter primarily affect the nerves of the part. The nature of the action countenances this idea, as it is immediate, and often powerful, but transient, so that in order to procure any permanent benefit, it is necessary for it to be continually repeated. Among the carminatives we may include the warm essential oils, as carui, anisum, anethum, and mentha piperita; also most of the stimulants, in moderate doses, and especially the aromatics, as cinnamomum and zingiber.

The three remaining classes of substances which increase action differ from those that we have hitherto examined, in not acting upon a mucous membrane, while they so far resemble each other, that the operation of each of them is upon a separate gland, the secretion of which they tend to increase. The glands in question are the liver, the kidney, and the uterus. The agents which act especially upon the liver, and thus promote the secretion of bile, we have called cholagogues; and although it is not easy to produce this specific effect, without, at the same time, either increasing the action of the alimentary canal, or of exciting the arterial system generally, yet there are perhaps few points of practice better established than the possibility of affecting the biliary system. The principal medicine which can be entitled to the appellation of cholagogue is mercury, especially when combined with cathartics. There are also certain cathartics, which, without the addition of mercury, act particularly upon the liver. Of these perhaps the most decisive in its operation is rhubarb, and we may also add colocynth, scammony, and the long continued use of the saline mineral waters.

The class of diuretics, those agents which operate in promoting the flow of urine, is more numerous than the cholagogues; they principally consist of acid vegetables and of neutral salts, but along with these there are certain substances, which it is difficult to reduce under any arrangement. The manner in which diuretics act, whether immediately upon the vessels of the kidney, in consequence of their having been absorbed and carried along the circulation, or whether the effect, although often speedy and decisive, may not be rather secondary and consequential, it is not easy to determine. Of the vegetable diuretics the most powerful are scilla, digitalis, colchicum, spartium, juniperi baccæ, and tabacum; of the saline diuretics the principal are potassa, both pure and combined with the carbonic, acetic, and tartaric acids, and especially under the form of potassæ supertartras, soda, and its different combinations, although less powerful than the salts of potash, and acetate of ammonia. To these may be added some substances of a different kind, spiritus ætheris nitrici, tinctura ferri muriatis, lytta, and, as being among the most powerful agents, although probably acting in consequence of their systematic effect only, we may place some of the preparations of mercury.

Lastly, we come to the substances which act upon the uterus, called emmenagogues, which, although of uncertain, and frequently of secondary operation, seem to be entitled to form a separate class of remedies. Of these perhaps the most powerful is sabina; some of the cathartics have been regarded as belonging to the emmenagogues, particularly the aloes; and we may also place in this class the warm bath and electricity, but it may be conjectured that the efficacy of this last agent depends principally upon the power which we have of applying it directly to the part affected.

Having now taken a view of the remedies which cause or increase action, we come to the second great division of the vital agents, those which diminish action. As a question of speculation there seems little necessity for employing any long train of argument to prove the possibility or probability of the existence of such a class of agents. If the well being of the system depend upon a certain degree of action, and a due proportion of its powers to each other, we might as reasonably expect to be able to diminish as to increase this natural action; and if we are able to apply certain means, by which the arterial and nervous system may be individually affected, there is as much cause for supposing that it is within our power to deprive them of a part of their ordinary energy as to augment it. Among the sedatives, or the agents which diminish general action, we may mention, as of first importance, and most direct operation, the detraction of blood, either by the lancet, by the scarificator, or by leeches. After this we may place low diet, which, although a negative remedy, produces a positive effect, and in the same way cold, or the abstraction of heat, when employed in sufficient degree, and for a sufficient length of time, proves powerfully sedative. Among the direct sedatives we may rank carbonic acid, and some other of the unrespirable gases, digitalis, and all those substances which immediately tend to relieve pain, stramonium, conium, belladonna, and bismuthi oxydum. The articles which we have placed in the next class, under the title of narcotics, may also be considered as sedative, although it is by a less general kind of opration that they produce their effect; but it must be allowed that, to a certain extent, every sedative proves narcotic, and every narcotic must be more or less sedative.

The phenomena of sleep are so peculiar and specific in their nature, and appear to be so much under the control of certain agents, that we have not hesitated to place these in a distinct class, under the denomination of narcotics. Whether they operate upon all parts of the system equally, or more immediately upon the brain and nerves, is a point which is not very easy to determine; at present we shall content ourselves with assuming the fact, that sleep depends upon a certain diminution of action, and is the primary operation of the substances in question. At the head of our list of narcotics we must place opium, to this succeed hyoscyamus, humulus, lactuca, and tabacum. There are other agents which may be regarded as decidedly narcotic, but it is probable that this is only a secondary effect. Whatever removes irritation or pain tends to promote sleep; so that, according to the nature of the irritation, there is scarcely an article in the materia medica, which, under some circumstances or other, may not come under this denomination.

The third class of this division, the antispasmodics, the object of which is to remove irregular action, indicates an effect which is well defined, and which we have frequent opportunities of witnessing, yet it may be doubted whether there be any substance capable of producing it, which has not been already placed in one or other of our former classes. In fact, irregular action proceeds from various, and even opposite causes; sometimes from an affection of the sanguiferous, and at other times of the nervous system, sometimes from a state of excitement, at other times of debility, and, of course, the remedies must be as various as the causes. There are, however, some agents to which this power may be considered as more specifically attached, and that in a degree which is not easily accounted for by attributing their efficacy to any other primary operation. Of these the most universally applicable is opium, afterwards we may place the sedatives generally, and we may add to them ammonia, æther, moschus, asafœtida, camphora, valeriana, and perhaps succinum.

We now arrive at the third division of the vital agents, those which increase strength. Our arrangement implies a distinction between strength and action; a distinction which is sufficiently well expressed by the terms as used in their common acceptation, and which seems to be founded upon a correct view of the nature of the animal economy. Many facts shew that action and power are not co-existent, and that, in some cases, they appear even to be in an inverse ratio to each other. By action, we mean the facility with which either the muscular fibre is brought into a state of contraction, or the nerve is excited to sensation; whereas by power, we mean the capacity which the muscle or the nerve possesses, of producing a quantity of effect without exhaustion. It may be laid down as a general principle, that whatever promotes the healthy state of the body ultimately produces strength, while, on the contrary, an increase of action is a frequent occurrence in disease, and what we are often obliged to counteract by the application of sedatives.

It has been supposed, that the quantity of nutriment received into the stomach, and properly assimilated there, is the sole foundation of all the means that can be adopted for increasing strength, and it no doubt constitutes one of the most effectual of them. We have accordingly given the first place to a class of substances which we have named Stomachics, the immediate object of which is to promote the function of digestion. The idea that we may form of the nature of their operation must depend very much upon our hypothesis respecting digestion, a subject which will be fully considered in another place; but we may here observe, that the stomachics probably act, in the first instance, upon the glands which secrete the gastric juice; they may also affect the mass of alimentary matter, and produce some change in the action of its component parts upon each other, or they may promote the propulsion of it from the stomach, and along the intestinal canal. The first of these operations is probably affected by the bitters, which we regard as the proper stomachics, a numerous tribe of substances, possessed of various degrees of efficacy: of these the most powerful are, gentiana, quassia, anthemis, and aurantii cortex, to which we may add columba, cusparia, cascarilla, and canella, which combine the properties of the bitters and the aromatics. The list of bitters might be much extended, as there is perhaps no country which does not produce a variety of plants, possessing this quality in a greater or less degree, and which have been employed by the inhabitants for medical purposes. Among the stomachics, which act on the alimentary mass, we may include the antacids, perhaps the antiseptics, and the aromatics, and we may also place in this class, although as operating upon a different principle, the cathartics and the carminatives.

The class of tonics are among the most important agents of the materia medica, and their effects are well defined, but, it must be confessed, that the mode of their operation is obscure. Their action would seem to be principally upon the muscular fibre, and to be brought about only by slow degrees, but when it is once established, it has a tendency to become permanent. It is not necessarily connected with a sensible change in any of the functions, nor do the tonic remedies possess any common property, physical or chemical, to which their power can be referred. Many of them exhibit a degree of astringency, and most of them act as stomachics, but still there is a peculiar or specific quality in certain agents, of imparting strength to the muscular fibre, which cannot be referred to either of these effects. The tonics may be divided into two species, the vegetable and the metallic. Of the former, the most powerful is cinchona, which, in its different varieties, is generally esteemed so efficacious, as to supersede many other substances which possess the same property in an inferior degree, such as serpentaria, salyx, and sweitenia. Cusparia and cascarilla may likewise be placed among the tonics, although they perhaps belong more strictly to the former class of the stomachics. Of the metallic tonics, the most important as to its general application is ferrum, which is employed under a variety of forms, and we may add to this, zinci oxydum, cuprum ammoniatum, argenti nitras, and arsenici oxydum, although the mode of their operation is doubtful. The mineral acids, especially the sulphuric and the nitric, on some occasions exhibit an action resembling that of the tonics, but it may be questioned, whether it is not more through the medium of the stomach, either upon the secretion of the gastric juice, or the mass of alimentary matter.

We have now gone through all the classes into which we proposed to divide the subjects of pharmacology, and we have arranged under one or other of them almost the whole of the agents which are generally admitted to possess any considerable effect in the cure of disease. Our classification is, however, confessedly incomplete, for while, on the one hand, there are certain articles which we have not been able to place in any of our classes, so there are likewise certain effects which we have not been able to include under our arrangement of actions or properties. Among the individual articles the situation of which remains undecided, is one of the most extensive operation, and of the most remarkable activity, mercury. By exhibiting it in various forms, by combining it with other remedies, and by varying its dose, it may be made to produce almost any one of the effects which characterize the various classes that fall under the first division of the vital agents. It is a powerful excitant, and it may assume the action of the stimulants, it may promote almost every one of the evacuations, by removing irritation it frequently proves sedative and antispasmodic, under certain circumstances it seems to be both a stomachic and a tonic, and, besides all these virtues, it has a specific effect over certain diseases which cannot be referred to any general principle. The antisyhilitic power of mercury is well known, and its action on some of the cutaneous diseases, although less certain and decisive, is sufficiently obvious, and seems to depend upon a different principle, and one which it is equally difficult to reconcile with the ordinary operations of remedies. The power of the citric acid in curing scurvy is as decisive as that of mercury over syphilis, and is equally specific; so likewise is that of sulphur in removing certain eruptive complaints, and to the same list we may add the colchicum, should the reports of its efficacy in removing gout be maintained by future experience.

We have stated, that there are certain effects of remedies which we are unable to arrange according to any legitimate principles of pathology, and which we therefore at present regard as objects for future inquiry. Perhaps what has been called the febrifuge property of certain agents ought to fall under this description; for although it is generally referred to the tonic power of the substances employed, there seems reason to doubt, whether in this instance we have not been advancing too rapidly in our attempts at generalization. The paroxysm of fever is cut short or prevented by the sudden application of cold, by cinchona, and by arsenic; and it is not easy to assign any one primary operation which can be supposed common to them all, or which we are able to point out as the specific mode in which they arrest the morbid condition that constitutes fever. We have mentioned the citric acid as a specific for scurvy; and perhaps we might introduce a class of antiscorbutics, were we not so totally ignorant of the nature of the proximate cause of the disease; for although there is no agent so powerful and certain in its effect as the citric acid, yet there are other vegetables which have an obvious influence over scurvy, but which do not contain any portion of this acid. Most writers on the materia medica have introduced a class of remedies, under the title of anthelmintics, which have been supposed to possess the appropriate quality of expelling worms from the intestinal canal. The power of the oleum terebinthinæ over the tænia is fully established; that of stannum and dolichos over the ascarides rests upon respectable evidence; and there are other substances which are supposed to act particularly upon the lumbricus, yet it is difficult to conceive on what principle they can all operate, why they should each of them be useful in one particular kind of worm only, or why indeed they should be of use in any cases of this description. But we shall not pursue this subject at present, as any further remarks which we may have to make concerning it will come with more propriety when, under the article MEDICINE, we treat of those diseases in which these specific actions seem to be indicated.

After this detail of the agents employed in medicine, arranged according to the power which they exercise over the corporeal functions, an important part of the science still remains, the individual description of all the substances which have been enumerated: in the first place, giving an account of their natural history, and the sources whence they are procured; and 2d, Of the mode of preparing and compounding them for the purposes of the practitioner. The elementary nature of this treatise will oblige us to pass over both of these topics in a concise manner. We shall, however, give a brief account of the natural history of some of the more important articles of the materia medica, and we shall afterwards offer a few observations on the latter topic, to which the name of PHARMACY has been applied, and which is generally regarded as a distinct department of the profession.

In giving an account of the aticles of the materia medica, we shall confine ourselves almost exclusively to those which enter into the pharmacopœias of London and Edinburgh; and of these there are some that we shall entirely omit or pass over with a slight notice, being either very seldom employed in medicine, or generally regarded as inert. We have, on the whole, thought it better to adhere to the alphabetical arrangement. The articles employed in medicine form so very inconsiderable a part of the whole system of natural objects, that when they are arranged scientifically they present only a few fragments of a methodical classification, while, for the most part, their nature as medical agents is entirely independent of their classification. Although we do not in all cases consider the nomenclature that has been adopted by the colleges of London and Edinburgh in their new pharmacopœias, to be the most appropriate that might have been selected, yet we have thought it necessary to employ it, as being the language which is sanctioned by authority, and which, therefore, ought to be exclusively used in medical prescriptions.

Acacia vera.—This is the plant which affords the gum arabic of the shops. It was formerly styled the Mimosa nilotica, but has latterly been removed by Professor Wildenow to his new genus Acacia. It is of the class and order Polygamia Monœcia in the Linnæan system, and is placed by Jussieu in his natural order of the Leguminosæ.* The tree grows in the sandy deserts of Africa, and the western parts of Asia, and the gum is procured from it by incisions made in the bark. Although it is probable that the purest kind of gum arabic which is employed in pharmacy is derived from the Acacia vera, yet there are other species of acacias, and perhaps plants of a totally different genus, which furnish a substance that, in its essential characters, almost entirely resembles this gum. It has been observed that the trees of this description are all covered with a bark which contains a quantity of tan. All the gum that was employed in medicine or the arts, was formerly brought from Arabia or from Egypt, whence its name was derived; and it was not until about 200 years ago, that the gum of Senegal was introduced into commerce. The adventurous and presevering naturalist Adanson, who explored the district of the river Senegal with so much assiduity, contributed to extend our knowledge of the trees from which the gum might be procured in the western parts of Africa; and at present nearly the whole of what is imported into Europe comes from that country. Some later accounts render it probable that a gum, which in all its essential properties resembles what we call gum arabic, is procured from the central parts of the African continent, and that this substance forms one of the articles of export with the inhabitants of Tombuctoo, which they exchange for the goods of various kinds that are brought to them by the caravans.

The purest and finest gum arabic is in the form of nearly transparent tears, generally of a light yellow colour, possessed of such a degree of brittleness as to bear being reduced to a coarse powder, and exhibiting a well-defined and shining fracture. It is without taste or smell, and is very little affected by the action of the air. It is soluble in water, and forms with it a perfect mucilage, which remains for a long time without decomposition, or exhibiting any tendency to putrefaction, although, under certain circumstances, the solution of gum is said to generate the acetic acid. There are very few chemical re-agents which have any action upon gum; but it has been found that silicated potash will precipitate it from its solution in water, when it exists there only in very small quantity, so as to be a delicate test of its presence. It has, however, been suggested, that this precipitation depends, not upon any action between the gum itself and the silicated potash, but that it is owing to a minute quantity of lime that always exists in gum. Like most other vegetable substances, gum is powerfully acted upon by nitric acid. Some experiments have lately been made on the elementary composition of gum, of which Gay Lussac and Thenard's are probably the most to be relied on. They determine its constituents to be,

Oxygen	50.84
Carbon	42 23
Hydrogen	6.93
	100.00

(*Research. Phys. Chim.* ii. 290.)

With respect to the medical properties of gum, it is included under our class of mechanical agents, and in the division of the demulcents. It is of considerable use in practical pharmacy as a vehicle for other substances, and its nutritive powers, which are supposed to be very great in proportion to its bulk, sometimes cause it to be exhibited as a restorative in cases of general debility, and especially in weakness of the stomach and alimentary canal.

Acetum.—Vinegar is a well known product of a peculiar kind of fermentation, which has obtained the specific name of the acetous. It is procured, by exposing a vinous fluid, or any which contains the elements of wine, to a temperature of about 80°, with the addition of some substance which may act as a ferment. The liquour gradually becomes thick and ropy, its heat is increased, and it discharges a portion of carbonic acid gas. Although vinegar is generally obtained from the fermentation of wine, or malt liquors, it may be procured from a mixture of substances that have not actually gone through the vinous fermentation; and of these the two that seem essential are sugar and mucilage. Pure sugar is no more capable of undergoing the acetous than the vinous fermentation. After a certain period, the fluid, which had become muddy, deposits its fæces, and again acquires a degree of transparency; its temperature is reduced to that of the atmosphere, the extrication of gas ceases, and it is found to have acquired the properties of acetic acid. Besides this acid, vinegar contains a variety of other ingredients; some vegetable acids, as the malic, the citric, and the tartaric, are found in it; it also contains a quantity of mucilage and tartarate of potash, a little alcohol, and generally a portion of sugar that had escaped decomposition: all these substances are disolved in a large portion of water. By distillation vinegar may be deprived of the greatest part of these impurities, and it then obtains the name of acetic acid: it still, however, retains a very large portion of water. To free it from the water it may be exposed to the action of intense cold, by which the water alone is frozen, or the usual method is to distil the acetate of copper, by which we procure the acid in a very concentrated state. This was formerly called radical vinegar, and its sensible properties differ so much from common distilled vinegar, that it was conceived to be a distinct chemical compound, and from the idea that it obtained a larger proportion of oxygen, it was called *acetic* acid, while the acid of common vinegar was named *acetous*. Later experiments have however proved, that there is no essential difference in the chemical constitution of the two substances, and that they only differ in the greater degree of concentration of the acid procured from the acetate of copper.

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* When no particular remark is made, the natural orders referred to are those of Jussieu, in his Genera Plantarum, 1789

For medical purposes, common vinegar, or such as has been simply distilled, is always employed; when in a tolerably pure state, it is of a reddish brown colour, has an agreeable odour, and a grateful acid flavour. Its specific gravity is extremely various, but it is generally a little greater than that of water. Vinegar possesses powerful antiseptic properties on animal and vegetable substances, and even when applied to the living body it seems to have the power of resisting what has been called the tendency to putrefaction in morbid parts, it relieves their fetor, and appears to retard their progress to decomposition. It has the property of correcting the unpleasant smell of the air of apartments that have been tainted with exhalations from the sick, and it has been supposed to remove the contagious properties of the atmosphere, and even of solid substances that have been exposed to infection. When applied externally, it is an astringent, and when taken into the stomach, at least in combination with the alkalies, it forms one of our most valuable sudorifics.

Acidum carbonicum.—Carbonic acid, or fixed air, as it was formerly termed, is an acid which is not capable of being exhibited in the pure state, except in the gaseous form. It is employed in medicine, in what are called effervescing draughts, and affords to the stomach an agreeable remedy in debility of that organ; when combined with water it forms an acidulous fluid, which has been occasionally used as a refreshing beverage in febrile complaints. Some trials were made a few years ago, on the respiration of the different species of gases, and especially of the carbonic acid gas, for the cure of pulmonary affections, but it has been found to be totally inapplicable and useless. The carbonic acid enters into the composition of many valuable articles of the pharmacopœia, especially with the alkalies and alkaline earths, but these will be arranged under their respective bases, as they derive their virtues rather from the earth or alkali, than from the carbonic acid with which it is united.

Acidum citricum. (See *Limon.*)

Acidum muriaticum.—The muriatic acid, which was formerly called marine acid, and is now, in conformity with a new theory of its composition, sometimes styled the hydrochloric acid, is procured from sea salt, of which, according to the views that we take of its nature, it is regarded either as an *educt* or a *product.* It is a very powerful agent in chemistry and the arts, and, when sufficiently diluted, is occasionally employed in medicine, internally as a tonic, or externally as a gargle. But the most important medical use to which this and the other mineral acids have been employed, is as a means of purifying the air from contagious miasmata, by being diffused through it in the form of a vapour. For this purpose, the muriatic, the nitric, and the oxymuriatic or chloric acids have all been employed, as well as various combinations of them, but the vapours of either the muriatic or the chloric are generally supposed to be the most active.

Acidum nitricum.—The nitric acid, which is a compound of the two elements azote and oxygene, in the proportion of one volume of the former to 2.5 of the latter, is perhaps the most active chemical agent of which we are in possession, and of late has been frequently employed in medicine. It was brought very much into notice a few years ago, as a specific for syphilis, and the first trials that were made of it in this country, appeared to confirm the account that had been received of its virtues. More repeated trials, however, have led us to suppose, that the nitric acid, although a powerful adjunct to other remedies, has nothing specific or peculiar in its action, and that the benefit which it produces depends solely upon its general tonic power, or upon its salutary operation on the digestive organs. The same remark may probably be applied to its effects in complaints of the liver. It has also been employed for the cure of hepatic affections externally, in the form of a bath for the lower extremities, but at present we are not in possession of sufficient evidence to enable us to decide upon its merits.

Acidum oxymuriaticum.—The oxymuriatic, or chloric acid, the aqueous solution of chlorine, according to the last nomenclature, is principally to be mentioned as an article of the materia medica, in consequence of its employment in fumigation, for the purpose of destroying contagion. It has, indeed, been prescibed internally is some cutaneous eruptions, and in scarlatina, but we have no very accurate account of its effects.

Acidum sulphuricum.—Sulphuric acid is prepared in large manufactories as an article of commerce: it was formerly procured by the distillation of green vitriol, but is now generally formed by the direct union of sulphur and oxygen during combustion. When perfectly pure, it is colourless, without odour, and of an intensely acid taste; it is heavy, and of a thick consistence, from which circumstance, as well as from its origin, it obtained the name of oil of vitriol. As it is always mixed with a portion of water, its specific gravity in a separate state can only be obtained by calculation, but the London College direct, that what is kept in the shops should bear to water the ratio of 1850 to 1000. From the most direct experiments, it would appear, that it is composed of 100 parts of sulphur to 150 of oxygen. It is never employed in medicine in its concentrated state, except occasionally in the form of ointment, but when diluted with water, under the title of acidum sulphuricum dilutum, it is an article of the pharmacopœia that is very frequently employed. Its action appears to be that of a tonic, and it is probably from this property that it has been found useful in profuse sweats and in hæmorrhagies, rather than from any astringent quality. It is likewise employed in febrile affections to relieve thirst, and to remove the sensation of heat.

Alcohol is the principle which gives their generic properties to all fermented liquors, and is the direct result of the fermentative process. The immediate product of this operation, however, is a fluid containing alcohol united to a great variety of other ingredients; but by distillation all of these, except part of the water, may be separated from the spirit, which then acquires its appropriate name and qualities. It is then nearly without colour, of a peculiar odour, and of a sharp burning flavour; the specific gravity of the purest alcohol of the shops is to that of water, as 835 to 1000, but this probably still contains about $\frac{1}{10}$ of its bulk of water. Alcohol is very extensively employed in pharmacy, as a vehicle for a varity of substances which it has the power of dissolving, and thus rendering more active and more easily miscible with other bodies; these solutions form the tinctures of the pharmacopœia. It is sometimes employed externally as a fomentation, or as an application for recent burns. When taken internally, and not as a vehicle for other substances, it is almost always employed in the form of wine, before it has undergone the process of distillation. Wine has generally been considered as one of the most powerful and diffusible stimuli, and it appears to be of that description which we have denominated excitants, acting nearly in an equal degree upon all the different organs or functions. If used in large quantity, it produces that peculiar condition of the nervous system which is styled intoxication, which no substance except alcohol is capable of exactly imitating. If alcohol be taken habitually in any considerable quantity, it produces very unfavourable effects upon the system, exhausting all its powers, and bringing on premature old age, as well as many specific complaints. The employment of alcohol in medicine has varied very much with the prevailing hypotheses of the times, and perhaps also with the character of the practitioner. Its use is now much on the decline, so that it will scarcely be going too far to assert, that upon the average, not $\frac{1}{100}$ part of the wine and spirits are prescribed at present that were thought necessary 25 or 30 years ago.

Aloë.—The aloe is a succulent plant of the class and order Hexandria Monogynia of the Linnæan system, and of Jussieu's order of the Asphodeli, different species of which are found in various countries both of the old and the new continent. There has been considerable difference of opinion among naturalists, what are the species from which the extract that is employed in medicine is prepared. The London College, upon the authority of Sir James Ed. Smith, determines them to be the spicata and the vulgaris; the former yielding what is called in the shops the Socotrine, and the latter the Barbadoes aloes. It comes to us in the form of a dark yellow or brown mass, which has a slight degree of brittleness, and a glossy fracture, capable of being reduced to a coarse powder, and of being partially softened, and rendered in some degree ductile by heat. Its taste is intensely bitter, and is generally considered very disagreeable; its odour is slightly aromatic. It is procured by pressing out the juice from the leaves, and afterwards inspissating it by heat; it is then exposed to the action of the air and sun until it is completely dried. The inspissated juice of the aloe seems to be compounded of an extract and a resin; but although it has been made the subject of experiment by several chemists, there is some uncertainty respecting the exact nature of its constituents, nor does it appear in what degree its component parts are possessed of any peculiar or specific property. See Braconnot, Trommsdorff, Bouillon La-Grange, and Vogel, in *Ann. de Chim.* lxviii. 11, 20, 155.

The aloe is one of our most common and valuable purgatives: it operates without weakening the digestive organs, or producing any general debilitating effect, and is generally supposed to act more immediately upon the large intestines, and especially upon the rectum. The evidence for this opinion is, that it causes the discharge of solid fæcal matter without the admixture of much water or mucus; and that, when it is taken in large quantity, it produces pain about the anus, and sometimes even a discharge of blood. These circumstances have probably been exaggerated; and we should also suppose that there is but little foundation for the commonly received opinion, that aloes are particularly useful in amenorrhœa. With respect to its employment in what have been called suppressed hæmorrhages, as we do not admit of the existence of such a morbid affection, so we must regard this supposed virtue as imaginary.

Althæa.—Althæa officinalis, or marsh mallow, of the Linnæan class and order Monodelphia Polygynia, according to Jussieu's system, of the natural order of the Malvaceæ, is one of our indigenous plants, which is used in medicine in consequence of the quantity of mucilage with which it abounds. Besides simple mucilage, it contains a portion of saccharine matter, which is extracted by alcohol. Water dissolves both the sugar and the mucilage: and the roots are said to contain so large a proportion of soluble matter, that the insoluble residuum is no more than one-tenth of the whole. Although it may be considered as possessing very nearly the same properties with gum arabic, yet, as the mucilage which is extracted from it is in a less pure form, and is liable to ferment by keeping, the marshmallow is chiefly used for external applications.

Alumen.—Alum is an earthy salt, composed of sulphuric acid united to alumine, together with a portion of potash. This substance is generally obtained from certain natural strata, that consist of a combination of clay and iron pyrites; by first subjecting the earth to a strong heat, so as to drive off certain inflammable matters which exist in it, then by exposure to air, by which the sulphur that it contains attracts oxygen, and becomes converted into sulphuric acid, and lastly by lixiviation, a super-sulphate of alumine is obtained, and potash is then added to form it into alum. The salt thus procured, the alum of commerce, has a regular crystalline form, and is composed, according to the latest experiments, those of Berzelius, of 34.23 parts of sulphuric acid, 10.86 of alumine, 9.81 of potash, and 45 of water, (*Ann. de Chim.* lxxxii. 258.) The nature of the salt is said not to be affected, if, instead of potash, we add to the sulphate of alumine ammonia, or a mixture of potash and ammonia, but the salt will not be formed if we employ soda. In medical practice alum is accounted one of the most powerful astringents, and is used with advantage in those cases where we wish to restrain increased glandular secretions. Its most frequent employment is in collyria, for that species of ophthalmia attended with a great discharge of tears, where there is not much active inflammation present, or where it has been previously subdued by evacuations. It has been extensively used by some practitioners in what is called passive hæmorrhagies from the intestinal canal, but there is perhaps always some difficulty in determining exactly what are the cases for which it is adapted, and probably our views on the pathology of these diseases, as well as of the remedies proper for them, have been much influenced by hypothetical opinions.

Ammonia, or volatile alkali, in its pure state, can be obtained only in the form of a gas; but it appears to retain all its characteristic medical properties when it is combined with water, forming the liquor ammoniæ of the *London Pharmacopœia.* It is a very powerful stimulant, capable of being exhibited only in small doses; and when applied externally to the skin, is no less active as a rubefacient. As a medical agent it is more useful in union with carbonic acid, composing a carbonate, or rather a subcarbonate, when it assumes the solid form, and still retains the properties of a powerful stimulant, although less violent than in its pure or caustic state. It likewise possesses the antacid properties of the other alkalies, or of the alkaline earths.

The *acetate of ammonia*, the spiritus mindereri of the old pharmacopœia, the combination of ammonia with the acetic acid, is a preparation that is very frequently employed in medicine, from its action as a diaphoretic, and, on this account, form the basis of various febrifuge mixtures, to which it is itself a useful adjunct. The *muriate of ammonia*, or as it was formerly termed, sal ammoniac, is also an article of the pharmacopœia, but is now only used externally. It has been supposed to possess what is termed a discutient power, and has been applied in the form of solution to indolent tumours of various kinds; but it may be doubted whether any benefit has been obtained, more than would have arisen from the application of the fluid without the salt.

Ammoniacum.—Gum ammoniac is a concrete substance, in the form of an irregular mass, composed of small tears of a light brown colour, nearly opaque, possessed of some degree of tenacity, and generally mixed with a quantity of extraneous matter. Until lately, we were ignorant of the plant which produces ammoniac; but, by sowing the seeds that are occasionally found in the gum, Professor Wildenow has discovered that it is the Heracleum gummiferum, (*Hort. Berl. Tab.* 53, 54.) Its taste is bitter and nauseous; it forms an imperfect solution with water, and also with vinegar, giving the fluids a milky appearance; it is likewise partially soluble in alcohol, and appears to be entitled to the appellation of a gum-resin. According to a late analysis by Braconnot, (*Ann. de Chim.* lxviii. 69.) 100 parts of it are composed of about 70 parts of resin and 18.5 of gum, the remainder consisting of a species of glutinous matter and water. Its medical properties do not seem to be very well defined; it is classed among the fetid stimulating gums, and it has obtained the reputation of being deobstruent, expectorant, and diuretic; but we conceive that its virtues have been much exaggerated, and, indeed, are of too indefinite and multifarious a nature to permit us to place much confidence in them.

Amygdala.—The almond is the kernel of the fruit of the Amygdalus communis, a tree belonging to the class and order Icosandria Monogynia, and to the natural order of the Rosaceæ. It is said to be a native of Syria, but is now completely naturalized in the south of Europe; and will even perfect its fruit in the most favourable parts of this island. It is remarkable, that there is no essential difference to be observed between the trees which bear the bitter and the sweet almonds, although the fruits themselves differ so much in their sensible properties. Both species of almonds have been lately analysed, the sweet almond by M. Boullay, and the bitter almond by M. Vogel, (*Journ. de Pharm.* Aug. 1817, and *Annals of Phil.* xi. 426.) A considerable part of the solid matter of both species has been found to consist of albumen, united to a quantity of oil, forming a compound which almost exactly resembles cheese in its physical and chemical properties; this caseous matter constitutes about four-fifths of the whole: it also contains about 6 per cent. of sugar. To these ingredients in the bitter almond is added a portion of the prussic or hydrocyanic acid, and a peculiar essential oil, upon the former of which, or upon a combination of the two, its characteristic sensible properties seem to depend. The sweet almond is sometimes employed in pharmacy, for the purpose of forming an emollient or demulcent fluid when triturated with water. Its pleasant flavour may serve as a recommendation, when the object is to induce the patient to take copiously of mild mucilaginous beverages, but it cannot be supposed to possess any medical properties which do not belong to many other substances, while it appears that there are some individuals to whom the almond, as well as the other oily fruits, are peculiarly indigestible. Although the bitter almond is frequently employed in cookery, for the purpose of giving flavour to various articles, yet the prussic acid is known to be a most virulent poison, and therefore we cannot but suppose, that if it were taken in sufficient quantity, and in an unmixed state, it must be more or less injurious. We have, indeed, been informed through the medium of the foreign journals, that prussic acid has been employed on the continent for the purpose of curing phthisis, (*Bulletin des Sciences* for 1817, p. 185.) but we should greatly doubt the correctness of the observations, as well from the nature of the disease as from that of the remedy.

Anisum.—Anise seeds are the produce of the Pimpinella Anisum, an umbelliferous plant, which grows naturally in the countries bordering upon the Levant, and is cultivated in many parts of Europe. The seeds contain an essential oil, which is considerably heating and stimulant, and possesses the same properties as an excitant and carminative with others of this class.

Anthemis nobilis.—This, which is the common chamomile of the shops, is a plant of the Linnæan class and order Syngenesia Polygamia superflua, and of the natural order of the Corymbiferæ. It is now completely naturalized in this country, (*Eng. Bot.* tab. 980.) although perhaps originally not indigenous. The flowers, which are the part employed in medicine, have a strong and somewhat aromatic smell, and an intensely bitter taste. The chamomile contains both a bitter extract and an essential oil, but its most valuable properties seem to depend upon the first of these ingredients. When taken in the form of a solid extract, or of a cold infusion, it is a powerful stomachic; it is, however, most frequently employed as a weak warm infusion, to promote the operation of emetics, which it may, perhaps, in some degree accomplish by means of its essential oil, which possesses a very nauseous flavour.

Antimony—is a semi-metal which naturally exists in combination with sulphur, from which the metal is easily separated; the ore itself having previously obtained the name of antimony, the pure metal was formerly called the regulus of antimony. It has been very much employed in medicine, under a great variety of forms; and, except mercury, perhaps no substance has been made the subject of so much experimental research. It belongs rather to a chemical treatise, than to one on materia medica, to describe all the preparations of antimony, or the mode of forming them; we shall briefly mention those only which are admitted into the last editions of our pharmacopœias. Of these the most important are the ore itself, or the sulphuret of antimony, antimonii sulphuretum; the oxide of antimony, or antimonium calcinatum; the prepared sulphuret of antimony, antimonii sulphuretum preparatum; the tartarized antimony, or antimonium tartarizatum; and the antimonial powder, or pulvis antimonialis. With respect to the oxide of antimony, it is necessary to remark, that the metal is capable of being combined with various doses of oxygen, the number of which have been differently stated by writers of almost equally great authority. But there are two oxides which are the best characterized, and which differ very essentially from each other in their action on the body, named, from the relative proportions of oxygen, the protoxide and the peroxide. Of these, the protoxide is a medicine very powerful in its effects, but of very uncertain operation, and is therefore seldom used; while the peroxide is scarcely soluble in the animal fluids, and possesses very little sensible action. The preparations of antimony that are usually employed, are the sulphuret, the peroxide, and the protoxide combined with the tartaric acid, composing the well known substance tartar emetic.

The medical effects of antimony appear to be of two distinct kinds, the one powerful and immediate, terminating in some evacuation, which, according to circumstances, may be either from the stomach, the bowels, the lungs, or the skin. The other is nearly insensible, but considerably efficacious, and seems to be chiefly confined to the skin. The former operation is generally had recourse to in inflammatory affections of the abdominal, or thoracic viscera, or even in cases not immediately attended with inflammation, but where the depletion of the system is supposed to be indicated. The insensible action of antimony is chiefly resorted to in cutaneous affections, and for this purpose probably the best preparation is the precipitated sulphuret. Antimony is now seldom employed as a mere febrifuge, or with the idea of directly counteracting the proximate cause of fever, nor is the plan of giving it in nauseating doses ever employed in the present day. The good effect of antimony in dysentery seems to be established by general observation, although it may perhaps be difficult to explain the mode of its action.

Argentum.—Silver in combination with nitric acid forms an article of the pharmacopœia, to which the older writers applied the name of lunar caustic. As it is prepared for medical purposes, the nitrate of silver is exposed to heat, by which the water of crystallization is expelled, and the salt is fused; in this state it is poured into moulds, and formed into sticks of a black colour and a hard consistence, in which a crystalline appearance may still be perceived. The nitrate of silver is chiefly employed externally as a caustic, but it is also not unfrequently used internally in epilepsy, and some other diseases of a similar nature, with apparent success. A singular effect has been observed, in some cases, to follow the long continued use of this medicine, viz. that the complexion has acquired a permanent black tinge. Although this change has only been observed in a few instances, yet, as it has never been noticed except where the medicine had been previously administered, there seems no reason to doubt that it depends upon the action of this substance. The cuticle is said to retain its usual colour, and therefore the change is supposed to be effected upon the rete mucosum.

Armoracia.—Cochlearia Armoracia, or horse radish, is a well known tetradynamian plant, the root of which is commonly employed for culinary purposes, on account of its acrid but grateful flavour, which appears to be produced by the combination of a pungent essential oil, and a sweet mucilage. Like other vegetables possessed of the same sensible properties, it is a powerful excitant, both when applied externally as a rubefacient, and when it acts on the system generally through the medium of the stomach. It frequently enters into the composition of gargles, for the purpose of increasing the secretion of the salivary and mucous glands of the mouth and fauces.

Arsenicum.—The oxide, or acid of arsenic, although the most virulent mineral poison with which we are acquainted, is capable, under proper management, of affording us a very valuable remedy. Arsenic is a semimetal, which is generally found in combination with some other metallic body, from which it is separated by exposure to a strong heat, in what is styled the process of roasting, in consequence of which it sublimes; when procured by this operation it is always united to a considerable portion of oxygen, and indeed acquires the properties of an acid. It is a white opaque substance, semi-transparent, and of a fibrous appearance, soluble in water and in alcohol; its taste is acrid, and it excites in the mouth and throat a burning sensation, and produces a peculiar feeling of constriction. On account of its extremely deleterious properties, and the facility with which it is at all times procured, cases of death by arsenic frequently become a subject of judicial inquiry, and it is consequently a very important point to be able to detect the most minute portion of it in the contents of the stomach, or in the residuum of any article of food that had been taken shortly before death. But, for an account of the tests that may be employed in these cases, we must refer to the modern systems of chemistry.

When arsenic is received into the stomach, in any considerable quantity, it appears to act as a direct caustic, first producing violent inflammation, and afterwards corroding, and actually decomposing the part to which it is applied. Whether it be by absorption, or by a peculiar vital action, not only the stomach, but the whole of the body is found to be considerably affected by it, so as to partake, in a certain degree, of the same tendency to decomposition. In order to counteract the effects of arsenic that has been received into the stomach, the first object is to dislodge the substance as speedily as possible by vomiting, if this has not been already accomplished by the natural efforts of the organ, and at the same time to take a large quantity of mucilaginous or oily fluids, which may act mechanically, by preventing the particles of arsenic from coming into contact with the surface of the stomach, in addition to which, it is often necessary to use general remedies for obviating inflammation, after the first violent effects have subsided. Various antidotes have been recommended, consisting of substances that are supposed to unite chemically with the arsenic, and render it inert, as sulphur; but we apprehend that no benefit can be gained by any applications of this kind.

Arsenic has been frequently employed in medicine as a caustic, especially in cancerous affections, and perhaps there may be some cases where it has proved beneficial, but it has been found so violent in its operation, and it has sometimes occasioned such unfavourable effects upon the constitution, that it is now generally abandoned as an external application by the more judicious practitioners, although it is still extensively used by the empiries. The effects of arsenic, as an internal remedy, are not very easy to explain upon any general principle; it appears to be decidedly efficacious in most diseases that assume an intermittent type, and especially in obstinate agues; it is useful in many cutaneous affections, and perhaps in some of those anomalous painful diseases, which are vaguely classed under the denomination of nervous complaints.

Asarum europæum, or *asarabacca*, as it is usually styled, is a plant which is indigenous in some parts of England; it belongs to the Linnæan class and order Dodecandria Monogynia, and to Jussieu's order of the Aristolochiæ. When received into the stomach it is said to be a powerful evacuant, but it is never employed in medical practice except as an errhine, where we wish to procure a discharge of mucus from the nose.

Assafœtida.—This well known gum-resin is ascertained to be the product of the Ferula Assafœtida, an umbelliferous plant which grows in the south of Persia. The substance is procured by cutting the roots transversely, when the juice exudes spontaneously from them; it is in the form of irregular masses, of a brown colour, opaque, and possessed of some degree of tenacity. Its odour is very fetid, and its flavour acrid and bitter; and although they are at first extremely unpleasant, yet by habit many individuals are said to become strongly attached to them. It is partially soluble in alcohol, and it forms with water a milky fluid; but both water and alcohol appear to be capable of suspending the essential oil on which its sensible properties probably depend. It is the most powerful of what are called the fetid gums, and from its action on the vital powers generally, and perhaps, in no small degree, from its effect on the external senses, it is often found a valuable remedy in affections of the nervous system, especially such as depend upon those irregular exertions which we call spasms.

Aurantium. The orange, which is the fruit of the Citrus Aurantium, a shrub belonging to the class and order Polyadelphia Polyandria, and to the natural family of the Aurantiæ, is more employed as an article of diet than of medicine. The rind of the variety Hispalense, the Seville orange, enters into several of the officinal preparations, as affording a grateful aromatic bitter, possessing some efficacy as a stomachic. The leaves and flowers of the orange contain a strong essential oil, and have been occasionally used in medicine, but they are now entirely neglected.

Balsamum Tolutanum.—This substance is procured from the Toluifera balsamum, a tree which is a native of South America, belonging to the Linnæan class and order Decandria Monogynia, and, according to Jussieu, to the natural order of the Terebintaceæ.* The balsam flows from incisions made in the bark; it is of a thick glutinous consistence, of a dirty yellow colour, and by exposure to the air becomes dry and brittle. It belongs to the class of vegetable products called balsams, a term which is restricted to those bodies which possess the general properties of resins, but which yield benzoic acid when treated with sulphuric acid. It has a fragrant odour, and an agreeable taste, and in consequence of these sensible properties is used in pharmacy, but it is not probable that it possesses any specific properties as a medical agent.

Barytes.—This is one of the primitive earths, remarkable for its great specific gravity, from which circumstance its name is derived. When taken into the stomach, in any considerable quantity, it is poisonous; but it has been strongly recommended by some practitioners, in combination with muriatic acid, as a remedy in scrofulous complaints, under the appellation of a deobstruent. It is, however, difficult to say what is the exact meaning that ought to be attached to this term, and even upon purely empirical grounds, it must be considered as very doubtful whether this substance has ever proved of any essential benefit as a medical agent.

Belladonna.—Atropa Belladonna, a Pentandrian Monogynian plant, of the natural order of the Solaneæ, is one of the tribe of vegetables called narcotic, which, when taken in any considerable quantity, produce violent effects upon the nervous system, and finally proves fatal. It has been exhibited in the form of powder, of infusion, and of extract. The latter is the preparation generally employed, although perhaps one of the least certain in its effects, in consequence of the alteration which it is liable to experience from the action of air and moisture, even when preserved with the greatest care. Like the other poisonous vegetables, the medical properties of belladonna appear to be of two kinds. In small doses it operates as a sedative, relieving pain, and that, as far as appears, by a direct action upon the nervous system; but if taken in large quantity, the effects are of a very different description: it then operates as a powerful evacuant upon the alimentary canal, but its action is so unmanageable, that it is seldom if ever desirable to have recourse to it. It possesses a remarkable power over the iris: whether applied to the eye itself, or to the neighbouring parts, the pupil is kept for some time in a state of permanent dilatation, an effect which is often had recourse to by oculists in the operation for cataract.

Benzoinum.—Benzoin is a balsam procured from the Styrax Benzoin, a tree which is indigenous in Sumatra, of the Linnæan class and order Decandria Monogynia, and of Jussieu's order of the Guaiacanæ. The balsam is brought to us in large masses, of a brown colour, and of a brittle consistence. It has a fragrant odour, and a bitter aromatic taste. By different processes, a large quantity of benzoic acid may be obtained from it, which, in consequence of the proportion in which it exists in this substance, has acquired its appropriate name. It is occasionally employed in medicine, and enters into some officinal preparations; but it is doubtful whether it possesses any medical properties which should entitle it to our notice.

Bismuthum.—Bismuth is one of the semi-metals, remarkable for the low temperature at which it becomes fusible, and which has, on this account, been long employed in some of the mechanical arts. Of late it has been recommended, upon very respectable authority, as a valuable remedy for pains of the stomach, when taken in the form of the white oxide. (Marcet, *in Med. Chir. Trans.*) Its employment as a medical agent has hitherto been confined to this one affection, and as we have no very accurate idea of the principle upon which it operates, we must at present rest our opinion of its virtues entirely upon empirical grounds.

Calumba, or *Columbo*, as it has been generally named, is the root of a tree, which was formerly supposed to grow in the island of Ceylon, but is now ascertained to be a native of Mozambique: it is a diœceous plant, belonging to the order of Menespermeæ, to which the name of Cocculus palmatus has been applied. (Berry, *in Asiatic Researches*, x.; Decandolle, *Sys. Nat.* i. 522.) It is brought to us in transverse sections of various diameters, from half an inch to three inches; it has a bitter and somewhat aromatic taste, which appears to reside principally in the bark. It consists of a large proportion of mucilage, united to that modification of resin which has been styled cinchonin; the greater part of it is soluble both in water and in alcohol, but the solutions are thick, and the tincture is not precipitated by water. For medical purposes columbo is one of the most valuable stomachics of which we are in possession; it is found to be particularly serviceable in that state of weakness of the alimentary canal which occurs after cholera and diarrhœa, and is useful in restoring the tone of the digestive organs after they have been weakened by fevers, or any other long protracted complaints.

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* This plant has been lately removed by Mr. Brown to the genus Myroxylon, under the natural order of the Leguminosæ. See Obs. on Smith's Herbar. p. 25.

Calx.—Lime is one of the most common of the primitive earths, and is of essential importance in some of the most useful arts of life. In its pure state it is soluble in water, and forms lime water, a fluid which is employed in medicine as an antacid; upon the whole, however, it may be doubted whether its place may not be more advantageously supplied by the alkalies, or by lime in combination with carbonic acid. This combination exists in a great variety of forms, but they all agree in their chemical properties, and in the relative quantities of the earth and the acid, which is about in the proportion of 56 to 44. (Marcet, in *Nicholson's Journal*, xx. 29.) When it exists in a soft and friable state it is called chalk. The medical properties of chalk are chiefly those of an antacid, and it is found particularly useful in those cases of diarrhœa, which seem to depend upon the presence of acidity in the stomach and bowels. In consequence of its absorbent power, it is sometimes applied to extensive ulcers or excoriations which are attended with a very profuse discharge.

Cambogia.—Gamboge is a gum-resin which is procured from the Stalagmitis cambogioides, a native of Siam and other parts of the E. Indies, of the Linnæan class and order Polygamia Monœcia, and of Jussieu's order of the Guttiferæ. There is some reason to suppose that other plants besides the above furnish a substance very nearly, if not entirely, similar to that which is usually found in the shops. Gamboge comes to us in masses of considerable size, of an homogenous texture, a shining fracture, and an orange yellow colour. It has but little taste or smell, it is nearly soluble both in water and in alcohol, and also in potash. According to the analysis of Braconnot (*Ann. de Chim.*) it consists of one part of gum to four parts of resin. The medical properties of gamboge are those of a powerful cathartic, and of that description which we term hydragogue, where the evacuations are very copious and watery. On this account it has been frequently used in dropsy, and probably in many cases with success, although the violence of its operation has been considered an objection to its general use. It has been supposed to be peculiarly serviceable in expelling the tape worm, but it may be questioned whether its success in this respect has been more than from other equally active purgatives.

Camphora.—Although it is probable that camphor is to be considered as a proximate principle of vegetation, which may be derived from a variety of different plants, yet it is furnished in by far the greatest abundance by a species of laurel, the Laurus Camphora, which is indigenous in Japan. The whole plant seems to be impregnated with this substance, but it is principally procured from the wood and the roots by distillation; after undergoing the process of refining, it is obtained in the form of a white, semi-transparent, crystalline body, of an aromatic pungent taste, and a strong specific odour. It is volatile and inflammable, soluble in alcohol, in oil, and in acids, but insoluble in water. A substance has been prepared artificially by M. Kind, a German chemist, which seems to resemble camphor in all its properties, by passing a current of muriatic gas through the oil of turpentine. (Thomson's *Chem.* iv. 121.) The sensible properties of camphor, as well as its immediate action on the body, would point it out as an active medical agent, and it has accordingly been much employed in medicine, yet there seems to be considerable doubt respecting its power over the body, or the nature of the effect which it produces. Its first operation is that of an excitant, yet it afterwards manifests sedative effects, which appear to be more than proportional to its primary action. It is a substance which has been frequently employed for the purpose of relieving spasms, an operation which is difficult to explain, and which may perhaps in different cases be effected by different kinds of actions. It has been supposed by some practitioners to be very efficacious in procuring sleep in mania, and it has been conceived to possess some specific action over the urinary organs, but we think that on both these points there is considerable uncertainty.

Capsicum.—Cayenne or Indian pepper is made from the pod of the Capsicum annuum, a plant which is a native of South America, of the class and order Pentandria Monogynia, and of the natural order of the Solaneæ. The taste of the pod when ripe is extremely pungent and burning; it depends upon a principle which is probably of a specific nature, soluble both in water and in alcohol, reddening blue vegetable colours, and precipitating many of the metallic salts. (Duncan's *Dispensatory*, p. 210.) Capsicum is principally employed as a condiment, and it is said that it may be taken in considerable quantity without producing those injurious effects which follow from the excessive use of other acrid substances. Its medical properties are those of a powerful excitant or stimulant, but it is not often administered except in the form of a gargle, in severe cases of cynanche maligna, where its topical action has been thought to be highly beneficial.

Cardamomum.—Cardamum seeds have long been used in medicine, and are the produce of a plant which was considered to be a species of Amomum, but which has been lately removed by Dr. Maton to a new genus, called Elettaria.* It is of the Linnæan class, and order Monandria Monogynia, and of the natural order of the Cannæ. Cardamum seeds afford a pleasant warm aromatic, which are in very general use, and enter into many of the officinal preparations; they possess the usual properties of this class of medicines, but are less heating and stimulant than some others of them, and are perhaps on this account better adapted for general use. Their specific virtue is extracted both by water and by alcohol, although, as appears, more perfectly by water.

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* Roxburgh, in his account of the plants of Coromandel, considers it to be an Alpinea

Carui.—The seeds of the umbelliferous plant, the Carum Carui, although principally employed as a domestic remedy, have obtained a place in the Pharmacopœia, on account of their carminative virtues, which they seem to possess in common with other plants of the same description.

Cascarilla.—There is still some difference of opinion respecting the name of the tree from which the cascarilla bark is obtained; in the last edition of the London Pharmocopœia it is styled the Croton Cascarilla; there is, however, reason to suppose that the plant to which this name was given by Linnæus, does not furnish the bark that we use in medicine, but that it is obtained from the Clutia Eleutheria of that author. (Murray, *Appar. Med.* iv. 129.) Cascarilla, as we receive it, is in the form of short pieces, rolled up very much in the manner of Peruvian bark, of a dark brown colour, of an agreeable odour, and a bitter aromatic flavour. It seems to contain both an essential oil and a bitter extract, which are soluble in water and in alcohol, although more perfectly in the latter medium. Its medical virtues are those of an excitant and a stomachic combined, and although not very extensively employed in practice, it would seem to be possessed of valuable properties.

Castoreum.—Castor is an animal product, derived from the beaver, consisting of a peculiar unctuous matter, which is secreted from a follicle situated near the anus. It comes to us enclosed in the bag itself, which is removed from the animal entire, and is afterwards dried. It has a disagreeable smell, and a nauseous bitter taste, and gives out its qualities to alcohol. It has derived considerable celebrity in medicine as an antispasmodic, and has been said to possess a specific action on the uterine system. We are disposed, however, to be very sceptical respecting this latter property; and, with respect to the former, we think it may be reasonably conjectured, that a large share of its supposed antispasmodic virtues are to be ascribed merely to its effect upon the sensations.

Catechu is an extract procured from a plant which is a native of Hindostan, of the genus Acacia or Mimosa. The extract is prepared by boiling the internal part of the stem, and afterwards evaporating the fluid. It is of a reddish brown colour, possesses a degree of brittleness and friability, and has a taste which is at first sweetish, but afterwards astringent. There are different species of it brought to this country from the East Indies, which differ a little in their external characters, but which seem to resemble each other very nearly both in their chemical and medical properties. According to the analysis of Sir Humphry Davy, catechu consists of about one-half its weight of tannin, and about one-third of a peculiar extract, combined with a portion of mucilage, and some extraneous substances. (*Phil. Trans.* for 1803, p. 233.) It is one of the most powerful and valuable astringents which we possess, and may be given with safety and propriety in all cases where we wish to restrain immoderate discharges, especially those from the bowels, when not attended with inflammatory action, or produced by congestion. It is a useful astringent as applied topically to the mouth and fauces.

Cera and *cetaceum.*—Wax and spermaceti may be enumerated among the most useful articles of the pharmacopœia for the purpose of external applications, especially as forming the basis of ointments of various forms and consistence.

Cinchona.—There are few articles of the materia medica which have been more generally celebrated than the Peruvian bark. It is procured from a tree indigenous in Peru and Chili, of the class and order Pentandria Monogynia, and of the natural order of the Rubiaceæ, of which there appears to be several species that possess nearly the same properties; but of these there are only three that are admitted into our pharmacopœias, to which, from the form of their leaves, the specific names of cordifolia, lancifolia, and oblongifolia, have been applied, designating respectively the common pale, the yellow, and the red bark. The analysis of Peruvian bark has been prosecuted with great assiduity, in proportion to its supposed importance as a medical agent, and various shades of difference have been accurately noticed between the different species, both with respect to their operation as chemical re-agents, and the relative proportion of their component parts. Among the earliest of the correct examinations of Peruvian bark, must be mentioned the very elaborate essay of Fourcroy, (*Ann. de Chim.* viii. 113.) and one no less deserving of our attention, which has been published more lately by Vauquelin, (*Ann. de Chim.* lix. 113.) Without going into a minute detail of these analyses, which would carry us far beyond the limits prescribed to this article, we may state, in general terms, that the essential constituents of bark are gum, gluten, a peculiar extractive matter, which seems to exist in different states of oxidation, portions of resin and of tan, and small quantities of earthy and of neutral salts. It is probable that the extractive matter is the substance in which the peculiar virtues of the bark more immediately reside; and from some circumstances connected with its relation to chemical agents, which were first accurately noticed by Dr. Duncan jun., it was considered by him to be a specific vegetable principle, to which he gave the name of cinchonin, (Nicholson's *Journal*, vii. 226.) One of the substances that has been detected in bark is a salt, which has been supposed by Vauquelin to be formed by a combination of lime and a peculiar acid, to which he gave the name of kinic. *Ann. de Chim.* lix. 162.

The medical virtues of Peruvian bark have been the subject of even more discussion than its chemical properties. When it was first introduced into Europe many eminent practitioners violently opposed its use, alleging that it produced very injurious effects upon the constitution, and that it ought to be entirely banished from pharmacy. By degrees, however, the opposition against it subsided, and we have long ceased to apprehend any of those dangerous consequences which were at first stated to ensue from its employment. It then became universally popular, and for a long time it was conceived to be a certain remedy for a variety of diseases, which were very different in their nature, and comprehended some of the most violent affections to which the human frame is subject. Of late, the current of opinion has taken a contrary direction; so that, during the last few years, the quantity of bark that has been employed, at least in this country, is probably not much more than one-half, or one-third, of what it was twenty or thirty years ago. The Peruvian bark was first made known in Europe as a remedy for ague, and it has fully maintained its reputation in this respect. How far its operation in the cure of intermittents is to be regarded as depending upon any thing of a specific nature may be questioned; for, although there is no natural compound which is superior to bark, or even quite equal to it, yet there are other substances, or other combinations of substances, which have the same febrifuge property. From its use in ague, it was at one time generally employed in fevers of all descriptions, but this practice is now very much discarded; so that, except in the latter stages of the disease, or rather where we merely wish to remove the consequent debility, bark is seldom prescribed. It has been found useful in all diseases that possess an intermittent type, although in other respects of a very different nature from ague; and it has been supposed to be peculiarly serviceable in all those affections which seem to arise from a tendency to decomposition in any part of the body, as in gangrene and in putrescent ulcers. Upon this principle it was, at one period, regarded as a specific in cynanche maligna; but we apprehend that not much confidence is now reposed in its power over this complaint. The effect of bark, as a general tonic, is considerable; but, as a stomachic, it is probable that it does not possess any virtue superior to many other substances, while there are not a few to which it is even inferior.

Cinnamomum.—Cinnamon is the bark of a peculiar species of laurel which is a native of Ceylon, but it is cultivated in other parts both of the East and West Indies. On account of the high value which has always been attached to this substance as an article of commerce, the management of the cinnamon plantations, and the method of preparing the bark, were made the subject of municipal regulations; and a strict system of laws upon these points, was enacted by the Dutch during the time that they were in possession of the island of Ceylon, (*Annals of Philosophy*, x. 346.) The best kind of cinnamon is in thin rolls, and is of a light brown colour, possessing a sweetish aromatic taste, with a degree of pungency. As a medical agent, it probably does not possess any properties which are not common to others of the stimulants; but, as an article for culinary purposes, it is by far the most esteemed of the aromatic spices, and has always, on this account, been regarded as one of the most costly and valuable products of the East Indies. Its specific virtues reside in an essential oil, which is separated from the woody fibre by distillation.

Colchicum.—Colchicum autumnale, or meadow saffron, is a plant of the Linnæan order and class Hexandria Monogynia, and of Jussieu's natural order of the Junci,* which is indigenous in many parts of Europe. It has been long known as a substance possessed of very acrid and very poisonous qualities, but was seldom employed in the regular practice of medicine, until it was of late brought into notice, as constituting the substance which gives its specific qualities to the celebrated gout medicine. There are, indeed, very strong reasons for believing in the reality of this connexion; and although, in some instances, where it has been employed in too large a quantity, or without the necessary precautions, it may have proved injurious, or even fatal, yet, upon the whole, there appears no reason to doubt of its efficacy in removing or curtailing the gouty paroxysm.

Colocynthis.—Colocynth consists of the internal part of the fruit of the Cucumis Colocynthis, a plant of the gourd species, which is a native of Turkey. It is a very active purgative, of the drastic kind, and, when taken in any considerable quantity, produces vomiting, and even dangerous effects upon the system at large. It is, however, uniform and certain in its operation, so that if it be not administered in too large a dose, it may be employed with safety, and constitutes, perhaps, one of the most efficacious cathartics with which we are acquainted, and is peculiarly useful, as it seldom excites nausea, or deranges the action of the digestive organs. We have no accurate analysis of this substance, nor is it known upon what specific principle its activity depends.

Conium.—Conium maculatum, or hemlock, is one of those umbelliferous vegetables which produce a deleterious effect upon the living body, but which, when employed in small doses, has been conceived to afford a very powerful remedy for some of the most fatal and obstinate diseases. The effects of a large dose of hemlock manifest themselves upon all parts of the nervous system: It produces vertigo, dimness of sight, tremor of the limbs, involuntary evacuations, and other symptoms of paralysis, which, if sufficiently severe, terminate in death. These effects do not, however, occur when the medicine is taken in moderate doses, and it then seems to possess the properties of a sedative, relieving violent pain, and promoting sleep. It has been reported to have the power of removing scirrhus, or even healing cancerous ulcers; but these virtues have been much exaggerated, if they are not entirely unfounded.

Copaiba.—The tree which produces the balsam of capaiva, the Copaifera officinalis, is a native of the West Indies and of South America; it is of the class and order Decandria Monogynia, and of the natural order of the Leguminosæ. The fluid which flows from this plant, although usually denominated a balsam, yet, as it contains no benzoic acid, is not strictly entitled to this appellation, according to the technical use of the term, but is more of the nature of turpentine, consisting of a resin combined with an essential oil. It is completely soluble in alcohol, and the oil may be separated by distillation, (Thomson's *Chemistry*, iv. 155.) The substance, in its entire state, is of a light yellow colour, nearly transparent, of a fragrant smell, and a pungent taste. It was formerly much employed in medicine, under the appellation of a corroborant and detergent; but we may venture to assert, that no very definite meaning was attached to these terms, and that its virtues were either imaginary or much exaggerated. It appears, however, to have some peculiar or specific action over the urinary organs; and it is still employed for the purpose of restraining mucous discharges from the bladder and urethra, although we conceive that its powers in this respect, as well as its mode of action, are very dubious.

Cuprum.—Copper, like all the other metals, in its pure state, has no action upon the body, but when combined with oxygen, or any of the acids, becomes converted into a virulent poison. It is, however, frequently used as an external application, and is sometimes given internally. Three of its salts are admitted into the pharmacopœia, the acetate, the sulphate, and what has been termed cuprum ammoniatum. The well known compound ærugo, or verdigris, is essentially a combination of acetic acid and copper, in which the copper is in excess, so as to form a sub-acetate. This salt has been generally prepared in the south of France, by forming alternate strata of plates of copper and of the refuse of grapes, after they have been employed in the making of wines. It is of a bluish-green colour, and in the form of a dry coarse powder, in which some imperfect traces of crystallization may be perceived. There is some doubt respecting its exact chemical constitution; the latest experiments which we possess on the subject would lead us to suppose that it is a compound salt, consisting of two distinct combinations of acetic acid and copper. It is employed in medicine as an escharotic, or as composing a stimulating ointment for scrofulous sores.

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* A new order has been formed by M. Decandolle, of which the colchicum forms the prototype, and which he has named Colchicaceæ, (*Syn. Plant. Gall.* p. 157.) To this order the name of Melantaceæ has been given by Mr. Brown. *Prod. Plant. Nov. Holl.* p. 272.

Cusparia is the name that has been assigned by the London College to the substance that was formerly called Angustura. The bark was originally brought from St. Domingo, and was supposed to be derived from a tree that was indigenous in the Spanish West Indies; but we are now informed that this account was incorrect, and that MM. Humboldt and Bonpland have discovered it to be the produce of a tree, not previously known, of the Linnæan class and order Pentandria Monogynia, and of Decandolle's order of the Simarubeæ, to which Wildenow has given the name of Bonplandia trifoliata, (Humboldt and Bonpland, *Plant. Equinox*, p. 57. tab. 97.) The bark, as it is usually brought to this country, is of a brownish-yellow colour, with a short and resinous fracture; it has a faint odour, and a warm, bitter, aromatic taste. It would appear that angustura contains gum, resin, and extract. Its medical properties are those of an aromatic bitter; and it may be considered one of the best stomachics, in simple weakness of the digestive organs, of which we are in possession. It is peculiarly serviceable as a tonic for the intestinal canal, after dysentery, or other obstinate affections of that organ; and probably, in almost all cases of this description, where cinchona was formerly employed, angustura will be found to be preferable. We are informed that it has no peculiar efficacy in the cure of intermittents. If this should be the case, M. Humboldt has been unfortunate in the specific name febrifuga which he has assigned to it.

Digitalis.—Digitalis, or foxglove, is an indigenous plant, of the class and order Didynamia Angiospermia, and of the natural order of the Scrophulariæ. All its parts, and more especially its leaves, possess a nauseous taste, and are found to exercise very remarkable effects upon the nervous system. When taken in large quantity, the foxglove produces dimness of sight, vertigo, vomiting, purging, convulsions, and finally proves fatal; but when exhibited in moderate doses only, it has been conceived by many practitioners to be one of the most valuable medicines in the pharmacopœia. It possesses the most remarkable property of diminishing the velocity of the pulse, in consequence, as it appears, of a direct action on the arterial system. Hence it has been administered with striking benefit in all complaints attended with excessive action of the heart, or with the inflammatory diathesis, and especially where, from particular circumstances, depletion has been thought to be contra-indicated. It is likewise a powerful diuretic; and probably, in dropsical affections of the chest, is one of the most efficacious remedies which we possess. Digitalis was at one period very much extolled as a remedy in phthisis pulmonalis; but it is generally admitted, that our expectations of benefit from it in this complaint were founded upon very insufficient evidence.

Dolichos.—The Dolichos puriens, or cowage, is a papilionaceous plant, indigenous in the West Indies, the pods of which are surrounded with a quantity of down, which has been warmly commended as a remedy for ascarides. Hitherto, however, it has been employed only by a few practitioners; and future experience must decide, how far it deserves the encomium which has been passed upon it.

Elaterium is the fecula of the Momordica Elaterium, a plant of the gourd species, which grows spontaneously in the South of Europe. It is one of the most powerful drastric purgatives which we possess, and is of that kind which has been called hydragogues, in consequence of the copious discharge of water which they procure. On this account it has been much celebrated in dropsy, and not, perhaps, without just grounds. The violence of its action has, however, prevented it from coming into general practice, yet it appears to be tolerably uniform in its effects; and we conceive that no unfavourable consequences need to be apprehended from it, if it be given in sufficiently small doses.

Ferrum.—Iron is the most generally diffused of all metallic bodies, and enters into the composition, not only of a vast variety of minerals, but also of many organized substances. It is said to be the only metal the operation of which on the body is essentially salutary, for, although there are others that, under certain circumstances, form valuable medicines, yet, when taken in any considerable quantity, they all seem to be decidedly deleterious. It is employed under various forms, either uncombined with any other substances in a state of mere mechanical division, united to oxygen as a protoxide or a peroxide, or in combination with some of the acids, as the carbonic, the sulphuric, the muriatic, the acetic, and the tartaric. Its action is probably not essentially dissimilar in all these different preparations, as we may suppose that the apparent differences between them principally depend upon their degree of concentration, or their comparative solubility in the stomach. When iron is taken in the pure state, it would appear to be inert, unless it meets with an acid in the digestive organs, so that this must be an uncertain, and therefore an improper, method of administering it. The peroxide, for the same reason, is objectionable, as it is probably nearly insoluble in the animal fluids in their ordinary state. The protoxide is a more active form; and when we wish to go through a gentle, but long continued course of the medicine, this or its combinations with some of the weaker acids, as the carbonic or the tartaric, will be found the most useful preparation. The sulphate and the muriate are more powerful in their operation, and are supposed to possess a more decided degree of astringency; but if this really exist, it may be supposed to be owing to their more concentrated form. The sulphate of iron has been thought to have the effect of destroying worms in the alimentary canal, and the muriate, when given in frequently repeated doses, to have some kind of specific operation in relieving spasmodic affections of the urinary organs. The primary action of iron appears to be that of a powerful tonic, and to this, perhaps, all its other effects may be referred. After it has been given for some time, it increases the energy of the arterial system, produces a florid complexion, and a sensation of heat in the skin, and generally increases all the excretions and secretions. It has the effect of giving a black colour to the fæces, but this is probably owing to the superfluous iron which is mixed with the contents of the alimentary canal, and which has never entered the circulation, or produced any effect upon the system. Iron is generally supposed to be injurious when the body possesses a tendency to inflammatory action, or even to a state of vascular repletion. It is said, under these circumstances, to give rise to headach, spasms of the stomach, cough, and hæmorrhagies of various kinds. Perhaps these effects have been a little exaggerated by the theoretical views of those who have recorded them.

Filix.—The root of the Aspidium Filix-mas, or male fern, is introduced into the pharmacopœia, in consequence of its reputed power in expelling different kinds of worms from the intestines, and particularly the tape worm. As, however, it is always taken either in combination with active purgatives, or is followed by them, there is reason to doubt, whether any part of the benefit is derived from the fern root itself.

Galbanum is an exudation from the Bubon Galbanum, an umbelliferous plant, which is indigenous in Africa. As it first issues it is a milky juice, which gradually hardens into semi-transparent yellow tears; it has a resinous smell, and an acrid bitterish taste; it is partially dissolved, both by water and by alcohol, and by distillation an essential oil may be procured from it. It has the reputed virtues of that class of bodies which are styled stimulating gums; but it seems very doubtful what its medical properties actually are, or whether, indeed, it possesses any that should entitle it to the rank which it holds in our pharmacopœia.

Gallæ.—The gall or gall nut, is an excrescence from a particular kind of oak, the Quercus Cerris, and is formed by an insect, the Cynips quercus folii, which deposits its ova on the leaves, and in consequence, as it appears, of some irritation which is thus excited, the gall grows round the egg, and forms a nidus for the young insect. There is perhaps no natural substance with which we are acquainted that contains so large a proportion of tan, amounting, according to the experiments of Sir H. Davy, (*Phil. Trans.* for 1803, 233.) to about $\frac{1}{4}$ of the soluble parts of the galls, and they are consequently among the most powerful vegetable astringents which we possess. They are, however, seldom used, except as an external application or forming astringent gargles, injections, or ointments.

Gentiana.—Gentiana lutea, of the class and order Pentandria Monogynia, and of the natural order of the Gentianeæ, is indigenous in many parts of Europe, and is perhaps the most powerful bitter which is a native of the temperate zone. The root is the part used in medinine, and the peculiar virtues of it may be extracted either by water or by alcohol. Besides the substance in which the bitter quality more immediately resides, it contains a considerable quantity of mucilage, which is soluble in water only. Gentian is one of our most valuable stomachics, possessing the properties of the class of bitter medicines in an eminent degree, and being free from the admixture of any other substance which renders it nauseous, or disagreeable to the digestive organs. It has been questioned, whether the bitterness of gentian and other vegetables, which possess this quality, ought to be ascribed to any peculiar principle, or whether it is not rather the result of the elements which compose the body itself. Dr. Thomson has given an account of a set of experiments on the bitter matter as extracted from quassia, and it will remain for us to examine, whether that procured from other substances exhibits the same properties. (*Chemistry.* iv. 53.)

Glycyrrhiza.—Glycirrhiza glabra, or liquorice, is a papilionaceous plant, the roots of which contain a large quantity of a sweetish extract, which has been frequently employed in medicine, especially as a domestic remedy for catarrhal complaints and various affections of the chest; its virtues are merely those of a combination of sugar and mucilage.

Guaiacum officinale is a native of the West Indies, of the class and order Decandria Monogynia, and of the natural order of the Rutaceæ. The wood of the tree contains a large quantity of a peculiar matter, of a resinous appearance, which either exudes spontaneously from incisions made in it, or is expelled from it by heat. Guaiacum, when thus obtained, is a body of a brownish green colour, semi-transparent, brittle, having a vitreous fracture, without much smell or taste, but exciting a strong sensation of heat in the fauces. It had long been considered as possessing all the chemical and physical properties of a resin, but from the experiments of Mr. Hatchett and Mr. Brande, we find that it has some remarkable peculiarities. (*Phil. Trans.* for 1805, p. 300, and for 1806, p. 89.) It is soluble in alcohol, æther, the alkalies, and some of the acids. With respect to its medical virtues, it is a powerful stimulant, promoting the secretions, and increasing the heat of the system; it is principally employed in chronic rheumatism, and has at different times obtained a high degree of reputation for its efficacy in relieving the pains which are left in various parts of the body by syphilis, or by the treatment which it has been thought necessary to undergo for the cure of this complaint.

Hæmatoxylon campechianum, a tree which is indigenous in Honduras, of the class and order Decandria Monogynia, and of the natural order of the Leguminosæ, has been introduced into the pharmacopœia as a powerful astringent, and seems to be possessed of this quality in a very considerable degree; its principal use is as a dyewood.

Humulus Lupulus, or hop, an indigenous plant of the class and order Diœcia Pentandria, and of the natural order of the Urticeæ, has been long employed very extensively for the purpose of giving a flavour to malt liquors, and has lately been introduced into medicine for its narcotic properties. There is reason to believe that it possesses this power, although it does not exist in a very great degree; but as it is united to a bitter extract, which is grateful to the stomach, it is occasionally found useful for medical purposes where opium is objectionable, in consequence of its injurious effect upon the digestive organs. The narcotic property appears to reside in a resinous aromatic principle of a volatile nature, so that in the usual method in which hops are employed in brewing, it is probably dissipated, and nothing remains but the bitterness.

Hydrargyrus.—The use that has been made of mercury as a medical agent, and the number of processes to which it has been subjected, are perhaps equal, or even greater than those of antimony. That it exercises a very powerful action on the human frame, we have daily and undoubted evidence, although there is considerable uncertainty concerning the nature of its action; and what may seem more remarkable, there are certain diseases, of which it has been thought by some persons to be the cause, and by others the remedy. It is not necessary to give an account of all the various forms under which mercury has been exhibited; at present, they may be reduced to 4 classes; 1. the pure metal; 2. its combination with oxygen; 3. its combination with sulphur; and 4. with acids. Of the oxides, there are two species, the protoxide and the peroxide, and we have it in combination with the nitric, muriatic, sulphuric, and acetic acids. Of these, the preparations that are the most commonly employed are the sulphuret of mercury, the hydrargyri sulphuretum rubrum; its protoxide, as it exists in the common mercurial ointment, and perhaps in the mercurial pills, the peroxide, forming the hydrargyri oxidum rubrum, and the hydrargyri nitrico-oxidum; its combination with nitric acid forming the base of the unguentum hydrargyri nitrati, that with sulphuric acid, forming the subsulphas hydrargyri flavus, and above all, its combinations with the muriatic acid, the two substances which were formerly called corrosive sublimate and calomel, names which we are still disposed to retain, as it is evident that those which have been adopted, both by the London and Edinburgh colleges, are inaccurate.

Many volumes have been written upon the medical virtues of mercury, and upon its action on the body; it may perhaps be correctly characterized as the most principal stimulant which we possess, and which, according to the mode of its exhibition, or according to the peculiar preparation which we employ, may have its action directed to different organs, or be rendered subservient to different purposes. It may be made to increase almost any one of the secretions, but those on which it acts the most remarkably are the fluids from the salivary glands, the bowels, and the skin, and accordingly the immediate effects which result from it are either those of a sialogogue, a sudorific, or a cathartic. The most general and extensive employment of mercury has, however, been as an antisyphilitic, and until very lately its powers in this respect have been regarded as affording one of the most undoubted examples of specific action, of a remedy the effect of which was not to be doubted, at the same time that the mode of its operation was unlike that of any other substance, and completely beyond our comprehension. As a general febrifuge, and especially as a remedy for the yellow fever of America and the West Indies, the reputation of mercury, under the form of calomel, has been very great, yet some of the most intelligent practitioners are now disposed to doubt whether in either of these cases, even in that of syphilis, it has any specific action, and whether its only effect be not that of a purgative, or at least may depend upon its improving the condition of the digestive organs. Some of the most beneficial effects of mercury are often derived from its combination with other substances, such, for example, as with diuretics and with cathartics, for the purpose of increasing their action, and with opium, for the promotion of diaphoresis. It is likewise employed very extensively as an external application for a variety of cutaneous affections, and it is probably the most active agent in the different anthelmintic medicines, whether prepared empirically or by the regular practitioner.

Hyosciamus.—Hyosciamus niger, or henbane, a plant of the class and order Pentandria Monogynia, and of the natural order of the Solaneæ, is one of the vegetable poisons which, when taken in small quantity, and with proper restrictions, has been converted into a valuable medicine. It possesses the properties of a narcotic, and has the advantage over opium of not constipating the bowels; it seems also that there are some constitutions in which hyosciamus is less apt to derange the stomach than opium, and where we may consequently employ it with more advantage, when we have occasion to persevere in its use for any considerable length of time.

Jalapa.—The Convolvulus Jalapa, a plant of the class and order Pentandria Monogynia, and of the natural order of the Convolvulaceæ, is a native of Mexico, and was first brought into Europe about the commencement of the last century. The root forms a well-known and valuable purgative, which is perhaps more generally employed than any other of vegetable origin, and, except that it occasionally produces nausea, it seems to possess every advantage that can be wished for in a medicine of that description. According to a late analysis, it is found to consist of resin, extract, starch, and the woody fibre, *Ann. de Chim.* lxxii. 275, but it is probable that all its active medical properties depend upon the first of these ingredients. When taken in large doses its operation is drastic, and even approaching to that of the hydragogues, but it does not appear to derange the functions of the bowels, or to produce any subsequently injurious effects, and by diminishing the dose its action may be reduced to the proper degree of mildness.

Ipecacuanha, which is as commonly employed for its emetic, as jalap for its purgative operation, is a native of various parts of South America, of the class and order Pentandria Monogynia, and of the natural family of the Rubiaceæ. For a long time the plant which produced it was not known, but we learn from unquestionable authority, that it belongs to the genus Callicocca, (*Trans. of the Lin. Society*, vi. 137,) or as Wildenow has since arranged the same individuals, to that of Cephaelis. There are several other plants, even of different genera, which possess an emetic property, to which the name of ipecacuanha has been applied, but that above mentioned seems to be the one in which it exists in the greatest degree, or at least which is usually employed for medical purposes in Europe. It has been lately examined with great accuracy by MM. Magendie and Pelletier, and is found to contain a specific principle, to which they have given the name of emetine, as it appears to be that on which the emetic property of ipecacuanha depends. (*Annals of Philos.* xi. 422.) It composes about one-sixth of the whole, and is united to a considerable quantity of starch, a portion of gum, a little wax, together with the woody fibre. The primary action of ipecacuanha is that of a direct emetic, acting speedily but mildly on the stomach, and effectually evacuating its contents, without producing any dangerous or disagreeable effects. If given in small doses, and under peculiar circumstances, its operation may be directed to the bowels, and in combination with opium, in the form of what has been called Dover's powder, it affords a most powerful sudorific.

Juniperus.—The common juniper, a plant of the class and order Diœcia Monodelphia, and of the natural order of the Coniferæ, has been introduced into the pharmacopœia under the character of a diuretic, but it probably possesses no powers of this kind, but what may be ascribed to its general stimulant effect upon all the organs of secretion.

Kino.—Although kino has been long admitted into the pharmacopœia, yet its origin remained unknown until it was discovered by Mr. Park, in his second expedition into Africa, in its native situation on the Gambia. From the specimen of the plant which he sent to England, it would appear to be a species of Pterocarpus, (*Journal of Park's 2d Exped. p.* 61.) but it seems that there is sold in the shops, under the appellation of kino, various substances, which, although agreeing in their general characters both physical and chemical, are easily distinguished from each other. Its appearance is that of a dark reddish brown mass, brittle, and of a resinous fracture. It was formerly supposed to be a species of resin, but the experiments of Dr. Duncan, jun. (*Nicholson's Journ.* vi. 234.) and of M. Vauquelin, (*Ann. de Chim.* xlvi. 221.) have proved that it contains a large quantity of tan, and that this is the ingredient on which its specific properties depend. It is one of the most powerful of the vegetable astringents, and agrees with them in all their effects upon the body.

Lactuca.—Lactuca sativa has been long supposed to possess an anodyne property, but we believe was never introduced into medicine, until it was lately proposed by Dr. Duncan as a substitute for opium, in those cases where this drug produces unfavourable effects upon the nervous system or the digestive organs. An extract may be prepared from the leaves of the plant, which contains its virtues in a concentrated form; it has a dark brown appearance and pitchy consistence, not very unlike that of opium.

Lavandula.—The flowers of the Lavandula spicata, or common lavender, although they have obtained a place in the pharmacopœia, and frequently enter into our prescriptions, should perhaps rather be regarded as a perfume than as an article of the materia medica. Its odour is extremely grateful, and it affords a useful vehicle for other articles, while, at the same time, its virtues as an excitant are not altogether to be disregarded.

Lichen.—The Lichen islandicus, or Iceland moss, has of late been highly commended for complaints attended with great debility, particularly those originating from diseases of the chest. We learn from the analysis of Professor Berzelius, that it is principally composed of mucilage and starch, together with small quantities of extract, of a bitter matter, and of other less important ingredients. (*Ann de Chim.* xc. 277.) We may conclude that its properties as a medical agent cannot be materially different from those of other articles that contain the same constituents.

Limon.—The lemon is the fruit of the Citrus medica, a tree of the class and order Polyadelphia Icosandria, and of the natural order of the Aurantiæ, and is the principal source of the citric acid, a very valuable article both for pharmaceutical and culinary purposes. Lemon juice, when properly diluted, is perhaps the most grateful and refreshing beverage that can be employed in febrile diseases, and possesses a very remarkable power in the cure of scurvy. For medical use it is now prepared in the concrete form, in which, although it is less pleasant to the palate, it retains its properties as a remedy for scurvy, and may be preserved without decomposition for any length of time. The rind of the lemon contains a very fragrant essential oil, which forms a pleasant perfume, and also adds to the agreeable flavour of recent lemon juice, as in squeezing the fruit a portion of the oil is pressed out at the same time. The rind has also a degree of bitterness, and enters into the composition of some stomachic medicines.

Linum.—Linum usitatissimum, the plant from which flax is prepared, is supposed to have been originally a native of Egypt, but is now completely naturalized in most of the warmer, or even temperate, countries of Europe. Its seeds contain a very large quantity of mucilage, and on this account are admitted into the pharmacopœia; their infusion is sometimes employed as an emollient beverage for complaints of the chest, and the seeds themselves are used externally in cataplasms.

Lytta.—The Lytta vesicatoria, or Cantharis, as it was formerly called, is one of the few animal substances which has obtained a place in the pharmacopœia, in consequence of its power as a vesicant. They are found in the south of Europe, and particularly in Spain, where they are said to grow to an unusually large size, from which circumstance they obtained their popular name of Spanish flies. Some experiments have been lately made by M. Robiquet, in order to detect the constituent on which their blistering property depends; by a complicated process he obtained a substance in the form of crystalline plates, of a micaceous appearance, which acted powerfully upon the skin; this he conceived to be the proximate principle on which their specific action depends, and he accordingly named it Cantharidin. (*Ann. de Chim.* lxxvi. 302.) We think, however, it may be questioned, in consequence of the various steps of the process by which the substance was obtained, whether this matter should not rather be regarded as a *product*, than an *educt*. Besides their use as an essential ingredient in blisters, cantharides are occasionally taken internally; they are a very powerful stimulant, and possess a specific action on the urinary organs and on the uterine system.

Magnesia is one of the primitive earths, of that class which is called alkaline, and is a frequent ingredient in various mineral substances; its appearance is that of a fine white powder, it has but little taste or smell, is insoluble in water, and combines readily in acids, forming with them neutral salts. It is employed in medicine as an antacid and a purgative, which latter effect probably depends, in a considerable measure, upon its meeting with an acid in the alimentary canal. In consequence of this union of properties, it is a valuable remedy for that species of dyspepsia which may be supposed to originate from the presence of acid in the digestive organs; and it is very largely employed in this way, not only in medical prescriptions, but in domestic practice.

Two of the salts of magnesia are also articles of the pharmacopœia, the carbonate and the sulphate. In its external appearance, the *carbonate of magnesia*, or rather the subcarbonate, which is the preparation described in the pharmacopœia, is nearly similar to the pure earth, nor does it differ much from it in its medical properties, being both antacid and purgative. The carbonic acid with which it is united becomes disengaged when it meets with any acidity in the stomach, and may produce a painful distension of the part, although in other cases it is conceived that the acid thus liberated may act favourably upon the digestive organs.

Sulphate of magnesia is a salt which forms a principal ingredient in many purgative mineral springs; it has a bitter nauseous taste, is very soluble in water, and forms one of the most generally efficacious purgatives which is employed in medicine. Its operation is promoted by being taken largely diluted, and in this way, especially when it exists in the natural waters, it is employed in various complaints of the digestive organs, and in visceral diseases, with very great success. It has been conceived to be highly serviceable in diseases of the skin, and in glandular affections of all descriptions; and, in short, there are few complaints which have not, at some time or other, been supposed to be relieved by the waters of which it forms a principal ingredient. Much, however, of the benefit obtained in these cases must be attributed to the circumstances in which the patients were placed, which are, for the most part, such as are the best adapted for improving the general health, and restoring the natural actions of all parts of the system.

Malva.—The common mallow has obtained a place in the pharmacopœia, in consequence of its containing a large quantity of mucilage, which renders it applicable to those purposes where we wish to obtain an emollient fluid, either for internal or external use.

Manna is an exudation from a species of ash, the Fraxinus Ornus, which is indigenous in the south of Italy and in Sicily. It is obtained in the form of concrete masses, or flakes, of a light yellow colour, and granular appearance; its flavour is sweet, but somewhat nauseous. Manna has been lately subjected to chemical analysis by M. Bouillon-la-Grange, the result of which was, that he found it to consist of two distinct substances, one nearly resembling sugar, and the other probably analogous to gum or mucilage, as when treated with nitric acid it was found to yield the mucous acid. (*Journal de Pharm.* for June, 1817.) The medical properties of manna are those of a gentle purgative, for which purpose it was much employed in practice, but it is now gone nearly into disuse, as we are in possession of so many substances that are more efficacious.

Mel.—Honey, though of vegetable origin, probably undergoes some kind of change in the body of the bee, before it is deposited in the cells. Its characteristic property principally depends upon saccharine matter, which seems to be combined with mucilage, and, according to the experiments of M. Cavezzali, it also contains a portion of some kind of acid. (*Ann. de Chim.* xxxix. 110.) Honey is only employed in medicine as a vehicle for other substances, or as entering into the composition of gargles; the tendency which it has to produce colic pains in the bowels is a strong objection to its internal use.

Mentha.—Two species of mint, the spearmint and the peppermint, are retained in the pharmacopœia, of which the latter is the most important, and is indeed the only one which can be considered as a medical agent. Its distilled water forms a useful vehicle for other substances, and its essential oil is one of the most valuable of our carminatives.

Mezereon.—The Daphne Mezereon, a plant of the class and order Octandria Monogynia, and of the natural order of the Thymelæa, is indigenous in this country, and is employed in medicine on account of the acrid properties of the bark, which, although nearly without smell or taste, when it is chewed, produces in the fauces the most burning sensation. It appears to be a powerful stimulant, and has been much celebrated in the later stages of syphilis, especially for those symptoms which are supposed to depend upon the disease having attacked the bones; but it must be acknowledged that its powers in this respect have been doubted by some of those who are the best capable of forming an opinion upon the subject. It is also said to have been very serviceable in various affections of the skin; but here, again, we have that kind of uncertainty which always attends the operation of medicines that are exhibited for the cure of chronic complaints.

Muschus.—Musk is an animal substance, found in a follicle situated in the abdomen of the musk-deer. It is in the form of small grains, of a dark-reddish brown colour, and with some degree of unctuosity; it is inflammable, has a strong taste, and possesses a powerful odour, which to most persons is very grateful, when not too much concentrated. Its sensible properties have rendered it an object of attention in the practice of medicine, to which its costliness may have contributed. By some practitioners it has been most highly extolled as a very powerful agent for exciting the nervous system, in cases of its irregular action or great debility; but we think it may be doubted, whether much of the virtue that has been assigned to it is not imaginary, or at least that its effects are very uncertain, and have been much exaggerated.

Myristica.—The nutmeg is the fruit of the Myristica moschata, a tree of the Linnæan class and order Monœcia Monandria, and placed by Jussieu in his natural order of Lauri,* is a native of the Molucca Islands. The nut is inclosed in a membranous substance, which forms what is called mace, and which, as well as the nutmeg itself, contains a large quantity of a hot, aromatic, essential oil. They are highly valued, although rather as condiments than as medicines; in the latter capacity they possess the usual properties of a stimulating aromatic on the system at large, and on the digestive organs in particular, while their grateful flavour renders them very useful as a vehicle for other substances.

Myrrha.—Although myrrh is a substance with which we have been acquainted from a very early period, yet we are still ignorant from what plant it is procured, but it is supposed to be a native of Abyssinia and Arabia. It possesses the chemical properties of a gum-resin, being soluble both in water and in alcohol, although its solution in water is opaque; it seems also to contain an essential oil. It has been lately examined both by M. Braconnot and by M. Pelletier, but their analyses do not entirely coincide. (*Ann. de Chim.* lxviii. 52. and lxxx. 45.) Its medical properties are those of a stimulant, and, like the other heating gums, it seems to have a power of increasing the secretions generally, but it may be doubted whether it possesses any of the virtues which have been ascribed to it, of acting specifically upon the uterine system.

Olivæ Oleum. The oil of the Olea europæa, a tree of the class and order Diandria Monogynia, and of the natural order of the Jasmineæ, which forms so important a part of the vegetable treasures of the south of Europe, is seldom employed in this country as an article of diet, or as an internal medicine, but is used as the basis of liniments, ointments, &c.

Opium.—This celebrated drug is the concrete juice of the unripe capsules of the Papaver somniferum, a plant of the class and order Polyandria Polygynia, and of the natural order of the Papaveraceæ. It is a native of the southern parts of Asia, but it appears to be capable of perfecting its seeds in our climate, and opium has been procured in England, which is stated to possess the same properties with that from Turkey or the East Indies. The best opium is considered to be that which is brought from Turkey; it is a compact substance, with a smooth fracture, of a dark brown colour, a bitter and rather acrid taste, and a peculiar odour. The extreme importance of opium, as a medical agent, has caused its analysis to be prosecuted with great attention, and a variety of experiments have accordingly been performed upon it. The greatest part of its substance, at least of that which seems to possess its specific properties, was found to be soluble both in alcohol and in water, and was described by the older writers as being of the nature of a gum-resin. M. Desrone published an account of opium, about 15 years ago, in which he anuounced the existence of a peculiar crystallizable salt, which was supposed to contain the essential constituents of the substance. (*Ann. de Chim.* xlv 257.) and an analysis of it was published shortly after by M. Serturner, but which differed considerably from that of M. Desrone. (Thomson's *Chem.* iv. 68.) M. Serturner has lately again turned his attention to the subject, and he now informs us that he has succeeded in procuring the narcotic part of opium in a separate state, and has given it the appellation of morphium. It is a crystallizable salt, which possesses many of the characteristic properties of the alkalies; like them combining with acids, and composing neutral salts. Besides morphium, he supposes opium to contain another peculiar substance of an acid nature, which he calls the meconic acid; it seems to exist united with the morphium, and we may conjecture that what M. Desrone obtained was the meconate of morphium.

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* Mr. Brown has made the myristica the prototype of a new family, the Myristiceæ. See Prod. Flor. Nov. Holland. p. 399.

The medical properties of opium have been celebrated for ages, as being the most active and efficacious of all substances for procuring sleep or easing pain; and the experience of all persons, both professional and unprofessional, must bear testimoney to the general correctness of this statement. But although we are so well acquainted with its effects, the mode of its operation has been a subject of the most violent controversy, and directly opposite opinions have been entertained respecting it; for while it has been regarded by many as a direct sedative, by others it has been supposed to be the most powerful stimulant. Into the merits of this controversy it is not our business to inquire; but, as a simple statement of facts, we may remark, that although, under certain circumstances, opium exhibits exciting properties, yet that its sedative effects are incomparably the most obvious, and those which as a medical agent it is almost our sole object to obtain. It is generally admitted that opium is less proper to be administered in a plethoric state of the system, or when inflammatory symptoms are present, that the stomach and bowels should not be loaded, and that the dose should not be greater than is necessary for producing the desired effect. The consequences that ensue from an over-dose of opium, and still more from a too long continued employment of it, are well known to be extremely injurious; and we occasionally meet with individuals who are unable to employ it, even in the smallest quantities, without derangement of the nervous system, or of the digestive organs.

Pix.—The different species of the Pinus, or the trees of the fir tribe, contain a large quantity of a resinous juice, which either flows from them spontaneously, or is obtained by the action of fire. The resin is the thus, or common frankincense of the shops, the abietis resina of the London pharmacopœia; that which is procured from the Pinus picea, the Pinus sylvestris, and some other kinds of fir, by incision of the bark, is usually called turpentine. When the resin is intended to be extracted by heat, the wood is cut into small billets, and piled up into a heap, which is then set fire to, and by condensing the vapour, a mixture of resin, essential oil, acetic acid, and charcoal is formed, which constitutes tar; this by boiling, so as to drive off all the more volatile parts, is converted into pitch. These substances are never used in medicine, except externally, in the form of ointment, in which state they appear to possess considerable efficacy in the removal of certain cutaneons affectious.

Plumbum.—Lead is one of the metallic bodies, which, under certain forms, has been much used as an external application. The preparations of lead that are the most generally employed, are the carbonate and the acetate, the former constitutes the plumbi carbonas, or ceruse; the latter either the superacetas, or acetas plumbi, corresponding respectively to the sugar of lead, and Goulard's extract, according to the relative proportion of the oxide of lead and the acetic acid. The salts of lead appear to be powerful astringents, but it is doubtful upon what principle they act; whether immediately upon the fibers, or more indirectly upon the vital properties of the part to which they are applied. They seem, in the first instance, to diminish inflammation and vascular action, but if the application be long continued, they appear to induce a state very much resembling partial paralysis, and this is even communicated to the system generally. Although lead is, for the most part, only employed externally, it has been given internally by some practitioners, in cases of hæmorrhage, and in complaints of the lungs, and it is said with decided benefit; but we conceive that its acknowledged deleterious properties, and the tendency which it seems to possess of accumulating in the system, and producing permanent sedative effects, must always render its use undesireable.

Potassa.—The vegatable alkali is occasionally employed in medicine in a pure state, but more frequently in combination with an acid. The properties of pure potash, when taken internally, are those of an antacid, but it is seldom used except externally as a caustic. The salts of potash that are admitted into the pharmacopœia are the carbonate, the acetate, the nitrate, the sulphate, and the tartrate. The properties of the carbonate are nearly the same with those of pure potash, except that they are much milder, so that, especially in its saturated form, it affords us one of the safest and most efficacious antacids of which we are in possession, while the carbonic acid which enters into its composition, when it is liberated in the stomach, produces upon this organ its usual tonic effects. The acetate of potash is generally regarded as a powerful diuretic, from which circumstance it acquired its old name of the diuretic salt. The nitrate of potash, or common nitre of the shops, has been long employed in medicine; although it would appear that its virtues are rather of a dubious or equivocal nature. When taken in large doses, it appears to act upon the system with extreme violence, and even to excite a poisonous or deleterious operation; in small doses it has been conceived to be sedative, cooling, and antiphlogistic, but we are disposed to believe that these properties have been assigned to it without any just foundation. The sulphate of potash is a mild purgative, but it is seldom employed, except as an ingredient in other compositions. The tartrate has also acquired the reputation of being a mild purgative and a diuretic, but these properties are perhaps more justly to be ascribed to a combination of potash with an excess of tartaric acid, constituting the cream or crystals of tartar of the old pharmacopœias. This salt has long enjoyed the reputation of being a powerful purgative, and is regarded by many modern practitioners as among the most valuable diuretics. When taken along with a large quantity of fluid, it proves relaxing to the bowels, and generally acts mildly, without exciting any unpleasant symptoms, when, at the same time, the flow of urine is often increased to a great degree, and dropsical effusions are thus entirely removed. It has been thought to be peculiarly serviceable in hydrothorax, and the anasarca that occurs after an attack of the scarlet fever.

Pyrethrum.—The root of the Anthemis Pyrethrum, or pellitory of Spain, is introduced into the pharmacopœia in consequence of the remarkable power which it possesses of exciting the action of the salivary glands. When it is chewed, or when a small portion of the tincture is held in the mouth for some time, it produces a very copious flow of saliva, and on this account is found useful in relieving certain species of tooth-ach; it has been recommended in paralysis of the tongue, and probably with some prospect of advantage.

Quassia.—Quassia excelsa, a tree of the Linnæan class and order Decandria Monogynia, and of Decandolle's natural order of the Simarubeæ, (see *Ann. Museum*,) is a native of some parts of South America and the West Indies. Both water and alcohol have the property of extracting from it its peculiar virtues, which are those of a very intense bitter As it is not attended with any nauseous flavour, and is without any other property except that of simple bitterness, it must be regarded as a very valuable stomachic, and one that we think might supersede many other substances of the same class.

Quercus.—The bark of the English oak contains a large quantity of tan, which has long rendered it a valuable article of commerce, and the same principle has caused it to be employed in medicine as an astringent; its use, however, is confined to external applications of various kinds.

Resina.—After the turpentine, which naturally exudes from various kinds of firs, has been subjected to the process of distillation, in order to obtain the essential oil from it, the residue consists of mere resin, which is employed in pharmacy for the purpose of forming certain external applications.

Rheum.—Rhubarb is the root of the Rheum palmatum, a plant of the class and order Enneandria Monogynia, and of the natural order of the Polygoneæ, which is a native of China and the contiguous parts of Russia. It comes to us in transverse slices, with a hole in the centre, which is probably made for the convenience of hanging it up to dry. Although the natural product of a much warmer climate, it appears capable of coming to perfection in this country, and even in the northern parts of it is cultivated with success. It is of a bright yellow colour and a fibrous texture; it has a peculiar smell and taste, which are easily recognized by those who have once perceived them. It contains a considerable quantity of extractive matter, and a large proportion of the superoxalate of lime and malic acid, (Bouillon la Grange, in *Ann. de Chim.* lxvii. 71.) but its odour, and even its medical properties, have been supposed to depend chiefly upon a principle which is volatile, and somewhat of a resinous nature. It has been long celebrated as one of the mildest vegetable purgatives, while it has, at the same time, a degree of astringency or tonic power, in consequence of which it acts directly as a stomachic. It is very extensively employed in the bowel complaints of children, and upon the whole seems to be entitled to all the commendation which it has received.

Ricinus.—The seeds of the Ricinus communis, a plant of the class and order Monœcia Monandria, and of the natural order of the Euphorbiæ, which is found native in many tropical districts, contains a very large quantity of a fixed oil, usually called castor oil; this, in its pure state, is nearly without taste and smell, although it is seldom obtained in this country without some degree either of rancidity or of empyreumatic flavour It is very largely employed as a laxative, and is one of the mildest, and, at the same time, the most efficacious with which we are acquainted, as it appears to act without producing any irritation or stimulating effect; it is peculiarly valuable in inflammatory affections, especially those of the alimentary canal itself, in the puerperal state, and in all conditions of the system where excitement would be improper. The only objection to its use is the nausea which is caused by it, and this is frequently so considerable, as almost to prevent its employment.

Rosa.—Different species of roses are admitted into the pharmacopœia, and enter into some of our officinal preparations; their only use, however, is as a vehicle for other substances, for which purpose they are recommended by their grateful odour.

Rubia.—The root of the Rubia tinctorum, or madder, a plant of the class and order Tetrandria Monogynia, and of the natural order of the Rubiaceæ, has been strongly recommended as possessing a specific action on the uterine system; but on this point we confess we are entirely faithless. From the property which it possesses of giving a red colour to the bones, madder has likewise been recommended as a remedy for mollities ossium, but this is a proposal which we conceive to be no less incorrect in theory than useless in practice.

Sabina.—The savine is a species of juniper, which is a native of the N. E. parts of Asia, and is admitted into our pharmacopœia, in consequence of its essential oil, which is peculiarly stimulating. When taken internally it is heating, is said to promote the secretions generally, and has been supposed to possess a specific action on the uterine system; but its reputed virtues are not sufficiently confirmed to permit us to risk the violence of its action. Externally, it is a valuable agent for keeping up the irritation of issues, and forms a useful ingredient in some ointments for obstinate cutaneous affections.

Sapo.—The combination of an alkali and an oil, forms the useful compound called soap, which may be regarded as one of the most valuable articles of domestic economy. In pharmacy, it is employed as a vehicle for other substances, especially in some preparations for external use; it was formerly a good deal employed as an antacid, but we have a substitute in the carbonated alkalies which is greatly preferable.

Sarsaparilla.—The root of the Smilax Sarsaparilla, a plant of the class and order Diœcia Hexandria, and of the natural order of the Asparagi, appears to be a native of the Spanish West Indies. It was imported into Europe as a specific for syphilis, not long after the appearance of that disease, and even to the present day maintains its reputation as a remedy for certain stages of it; but we are disposed to think without any just foundation.

Scammonea.—The Convolvulus Scammonea is indigenous in the western parts of Asia. Its roots contain a milky juice, which, by cutting them transversely, flows out, and produces the scammony in its pure state; but it is supposed that we seldom obtain it without its being much adulterated. It is a substance of a greyish brown colour, friable, with a resinous fracture, of a nauseous taste, and disagreeable odour. It is principally composed of a resin, with small quantities of gum and extract, combined with a considerable proportion of what seems to be extraneous matter. (*Ann. de Chim.* lxxii. 69.) The medical properties of scammony are those of an active purgative, which operates briskly and copiously, and seems to be peculiarly effecutual in removing from the bowels all collections of sordes that may have impeded their regular functions. It sometimes causes griping; but when taken in proper doses, and at due intervals, it may be considered as amongst the most valuable cathartics that we possess.

Scilla.—The Scilla maritima, or squill, is a bulbous plant, which grows on the shores of the Mediterranean, the roots of which contain a very acrid juice, which gives the squill its medical properties, those of a powerful stimulant, especially to the stomach and urinary organs, so as to cause violent vomiting, catharsis, and strangury, when taken in large doses. It is, however, always employed in small quantities, by which means it operates on the kidneys as a diuretic, and perhaps forms the most useful medicine of this class of which we are in possession. The squill, in still smaller doses than those in which it operates on the kidney, is a useful expectorant.

Senega.—Polygala Senega, a plant of the class and order Diadelphia Octandria, and of the natural order of the Polygaleæ (Jussieu, *Mem Mus.* i. 385.) is a native of the United States of America. The senega, or rattle-snake root, as it has been called from its figure, possesses a considerable degree of heat and pungency, which is conceived to reside principally in the bark, and to depend upon a resinous matter contained in it. Its medical virtues are those of an excitant, and it has been supposed to act more particularly upon the mucous membrane of the lungs and trachea; but although it is a medicine which has been highly commended by some practitioners, it does not appear in this country to have risen into very general estimation.

Senna.—The shrub which produces senna is a species of cassia, which is indigenous in Egypt, the leaves of which have long been extensively employed in medicine as a purgative. They are of an ovato lanceolate form, pointed at the end, of a yellowish-green colour, and a nauseous bitter flavour. They have been examined by M. Bouillon la Grange, and it would appear that their active properties reside in a species of extract; small portions of several neutral and earthy salts are likewise obtained from them. (*Ann. de Chim.* xxvi. 3.) The purgative quality of senna has rendered it a very general remedy, both in professional and domestic practice, and, except its nauseous taste, and a degree of griping which it occasionally induces, it may be considered as one of the most valuable of the vegetable cathartics. It is very frequently prescribed in combination with medicines of the same class, and their efficacy appears to be mutually exercised by their union.

Sinapis.—The seeds of the Sinapis nigra, or common mustard, in consequence of the acrid stimulating oil which they contain, are very generally employed for culinary purposes, and are sometimes made use of as a medical agent. The seeds, when swallowed whole, act as a grateful stimulant upon the digestive organs, and seem to excite the system generally. Externally, mustard is employed as a rubefacient, and as the basis of different applications for the purpose of stimulating the surface of the body.

Soda possesses nearly the same medical properties with potash, but it is less frequently employed; it would appear, however, to be equally powerful as an antacid, and it has been thought by some persons to be more favourable to the action of the digestive organs, when taken habitually for this purpose. It is seldom employed in its pure state, but its combinations with the acids are some of them much used. Of these the carbonate, the sulphate, the tartrate, and the borate, are admitted into the pharmacopœia. The carbonate has probably the same medical effects with the carbonate of potash; the sulphate, the well known Glauber's salt of the older writers, is a remedy very extensively used in domestic practice; its operation is mild, but effectual, yet its nauseous flavour constitutes a strong objection to it. The Soda tartarizata of the London Pharmacopœia is a triple salt, composed of the tartaric acid combined with both the fixed alkalies, and is also an effectual and mild purgative. The phosphate of soda, although not introduced into the Pharmacopœia, is frequently employed in practice as a cathartic; it possesses the recommendation of being nearly as active as the sulphate, while it is much less disagreeable to the taste. The borate, or rather the sub-borate of soda, is found naturally in an impure state in some lakes of Asia and Thibet, and is purified in Europe by a process which is kept secret. It has been at different times much employed in medicine, and various effects have been attributed to it, which are, probably, in a great measure unfounded. At present it is seldom used except in the form of a gargle, in consequence of its being supposed to possess a peculiar power in removing aphthous crusts from the fauces, or restraining excessive salivation.

Stannum.—Tin has obtained a place in the pharmacopœia, from its property of expelling worms from the alimentary canal. It is employed in the form of a coarse powder, and is generally accompanied or succeeded by purgative medicines, so that it is doubtful what share of the benefit is to be ascribed to the tin; any effect which it produces is probably due to its mechanical action.

Strammonium.—The Datura Strammonium, or thorn apple, a plant of the class and order Pentandria Monogynia, and of the natural family of the Solaneæ, is one of that tribe of plants which possess a most powerful and deleterious action on the system, but which, when cautiously administered, are capable of becoming very useful medical agents. It has been lately recommended, upon high authority, as a remedy for severe pain, which it appears to remove by a kind of direct or specific action, and without producing any unpleasant secondary effects. The inhalation of the fumes of stramonium has been very warmly recommended as a remedy in spasmodic asthma; and although it may have frequently failed, yet there seems to be no doubt, on the other hand, that it has occasionally been efficacious.

Styrax.—Styrax officinale is a tree of the class and order Decandria Monogynia, and of the natural order of the Guaiacanæ, that grows in the Levant and the southern parts of Europe. The substance called storax flows from incisions made in the bark, and occurs in the form of large masses of a dark brown colour, and of a pleasant aromatic smell and taste. The benzoic acid may be obtained from it by the proper process, so that it is to be considered as a balsam, containing this acid in combination with a resin. It has obtained a place in the pharmacopœia, like many other of the oriental gums and resins, probably more from its sensible properties, than from any medical effect that has been obtained from it.

Sulphur is one of the simple combustible substances, which is frequently found in the neighbourhood of volcanoes, and is procured very abundantly by heating pyrites, a mineral in which it exists in combination with iron. It was employed in medicine by the ancients, and still retains its place in the pharmacopœia. When taken internally it is laxative, and appears to have the property of pervading the whole system in a remarkable manner, so as even to affect the skin, and act upon the cutaneous perspiration, from which circumstance it has been much employed in eruptive diseases, and has been conceived to possess a specific power over psora, whether used internally or externally. In the form of ointment it is a valuable remedy in many cutaneous diseases.

Tabacum.—Nicotiana Tabacum, a plant of the class and order Pentandria Monogynia, and of the natural order of the Solaneæ, is a native of America, and was brought into Europe soon after the discovery of that continent, on account of the agreeable effects produced on the system by the inhalation of its fumes. This peculiar effect, which bears some resemblance to intoxication, is excited by an essential oil, which, in its pure state, is so powerful as to destroy life even in very minute quantity. When received into the system, its first effects are to produce violent vomiting and catharsis, to which succeed vertigo, dimness of sight, difficulty of respiration, and all those symptoms which indicate an extraordinary derangement of the powers of the nervous system. In small doses it has been found very efficacious as a diuretic, although its deleterious properties must always prevent it from coming into general use; it has been employed externally with success in some cutaneous complaints, and obstinate constipations have been relieved by injections of tobacco, where every other means have failed.

Tamarindus indicus, a plant of the class and order Monodelphia Tetrandria, and of the natural order of the Leguminosæ, is supposed to be a native of both the East and West Indies, and produces a fruit which has been long valued for its agreeable acid flavour, depending, as it seems, upon a combination of the citric, tartaric, and malic acids. It is a mild laxative, and the infusion forms a very salutary beverage in febrile complaints.

Terebinthinæ oleum.—The oil of turpentine, as we remarked above, is produced by distilling the resinous exudation of various kinds of fir. It is a light, transparent, volatile, inflammable fluid, possessed of a hot, pungent taste, and having the properties of a powerful stimulant. Hence it has frequently been had recourse to in chronic rheumatisms, especially in those forms of it which have been called lumbago and sciatica. It is sometimes used externally as a rubefacient, and it is one of the most powerful agents with which we are acquainted in stopping hæmorrhage, when it is applied hot to the mouth of the bleeding vessel. It has lately been administered in large doses for the expulsion of the tape worm, and, as it would appear, with great success; it is perhaps upon the same principle of its destroying certain species of intestinal worms, that the oil of turpentine has been found serviceable in some species of epilepsy. Turpentine injections are found occasionally very effectual in relieving obstinate constipation.

Tragacantha.—The Astragalus Tragacantha, a plant of the class and order Diadelphia Decandria, and of the natural family of the Leguminosæ, is a native of the island of Candia, and some other parts of the Levant. In the beginning of the summer, a mucilaginous matter exudes from the branches, which is collected in the form of irregular worm-shaped masses, of a dirty white colour; it differs from gum in being less brittle, or even somewhat of a tough consistence, and in being insoluble in water, except in very small quantity; it is, however, capable of imbibing a large portion of this fluid, when it swells out very considerably, and forms a soft pulp. It is, for the most part, differently affected by chemical agents from gums, and is indeed unlike it in many of its properties, both chemical and physical. Its principal use in pharmacy is to form troches, and to serve as a vehicle for other bodies.

Valeriana officinalis, a plant of the Linnæan class, and order Triandria Monogynia, and of Lamark and Decandolle's natural order of the Valerianæ, (*Syn. flor. Gall.* 296.) is found indigenous in many parts of this island, and is remarkable for the peculiar fetid odour of its roots; their flavour is bitter and acrid, and they are generally regarded as powerful agents in various affections of the nervous system. Valerian contains an essential oil, and a peculiar extractive matter, both of which, it is probable, contribute to its virtues. It is often employed in combination with ammonia, and in this state is found to be a very effectual remedy for what are called nervous headachs; it has also been a favourite remedy for epilepsy, and it would seem, on some occasions, with evident success, although, like other remedies for this complaint, it is often found to be ineffectual.

Vinum. See ALCOHOL, p. 414.

Uva ursi.—The Arbutus Uva ursi, or red trailing arbutus, is a plant of the class and order Decandria Monogynia, and of the natural order of the Ericæ, which is indigenous in the mountainous districts of some of the northern parts of this island. Its leaves contain a considerable quantity of tan, and are powerfully astringent, so that in some countries they are employed in the manufacture of leather. Uva ursi has been strongly recommended as a remedy for complaints of the urinary organs; but if it possess any powers in this respect, it is probable that they depend more upon its action on the digestive organs than on the kidney or bladder.

Zincum.—Zinc, like other metals, has no action on the body in its pure state, but when combined with oxygen or with acids, it becomes an active medicine. Three of its preparations are admitted into the pharmacopœia; its native ore or calamine; its oxide, the calcined zinc or flowers of zinc; and its sulphate, or combination with sulphuric acid, forming what has been called white vitriol. Calamina, or calamine, is an ore of zinc, which consists of an oxide of the metal united to carbonic acid; from the analysis of Mr. Smithson, we learn that the English species consists of about 65 parts of the oxide, united to about 35 of carbonic acid. (*Phil. Trans. for* 1803, p. 12.) Calamine is employed in medicine only as an external application; it enters into the composition of washes and ointments for the eyes, and is applied to ulcers and excoriations of the surface, where the discharge is too profuse; its effects appear to be those of an astringent. Oxidum zinci, or the oxide of zinc, is composed of about four parts of the metal to one of oxygen, (Thomson's *Chem.* i. 418.) and is in the form of a white flocculent powder, without taste or smell; it is generally employed as an ingredient in astringent ointments, but is occasionally used internally as a tonic or anti-epileptic; its virtues in this respect are however yet scarcely confirmed. The sulphas zinci, or sulphate of zinc, possesses the medical properties of the oxide in a more active state, being one of the most powerful astringents for external use which we possess; when taken into the stomach it is a most speedy and effectual emetic, and is on this account the best medicine of the description that can be employed where poison has been swallowed, or where, from any other cause, we wish to produce an immediate evacuation of the stomach. According to the analysis of Berzelius, the crystallized sulphate of zinc consists of about 31 parts of acid, 32.5 of oxide, and 36.5 of water. *Ann. de Chim.* lxxxii. 120.

Zingiber.—Zingiber officinale, a plant of the class and order Monandria Monogynia, and of the natural order of the Cannæ, is a native of Asia, but is now completely naturalized in the West Indies. The root contains a large quantity of a hot aromatic oil, which renders the plant one of the most valuable vegetable stimulants with which we are acquainted. Although its action is powerful, the subsequent effects are less injurious than from other kinds of heating spices; and, upon the whole, so far as its medical properties are concerned, it might be regarded as nearly superseding all the rest. Its agreeable flavour has rendered it an article of great consumption for domestic purposes, and the same favourable character may be given of it as a condiment that we have bestowed upon it as a medicine.

Pharmacy.

The custom, which at present prevails in all civilized countries, of referring the exercise of pharmacy to a distinct set of persons, seems not to have existed among the Greeks, and to have been adopted by the Romans only in an imperfect manner; for the term *Pharmaceutice*, which is employed by Celsus to designate one of the three parts, into which the practice of medicine was divided, is not supposed to relate to the mere composition of drugs, but to a kind of mixed practice, resembling that of the surgeon-apothecaries of modern times. The complicated and multifarious pharmacy, which was introduced into medicine about the commencement of the Christian æra, and was confirmed and still farther promoted by the authority of Galen, necessarily produced a greater degree of attention to this art, and the subsequent introduction into medicine of what may be properly called chemical preparations, and which was, in the first instance, accomplished by the Saracens, seems to have made the preparing and compounding of drugs to be regarded as a distinct occupation. When the science of chemistry became more particularly attended to, and especially, after the direct application of it to medicine by Paracelsus and his followers, this arrangement was still more necessary, for a great proportion of the processes that were employed were recommended as much by their difficulty, and the length of time necessary for their completion, as by the virtues of the substances which were the result of them. And the practices of the Galenic pharmacy were scarcely less tedious and operose than the chemical; the number of the articles employed, and the nature of the processes to which they were subjected, were, if possible, even the more complicated of the two, and if they are to be regarded as less important, it is principally to be ascribed to the less active nature of the ingredients that enter into their composition. The change that took place in pharmacy during the course of the last century, is to be considered as one of the most efficient improvements that occurred in any part of the science of medicine. It led to a reform in theory as well as in practice, by enabling us to judge more correctly of the operation of agents upon the body, when they were administered in a more simple form, and were unencumbered with that superstition and mystery, which had remained attached to them since the period of the dark ages.

No one circumstance tended more to the improvement of pharmaceutical knowledge than the practice, which began to prevail in the 16th century, of publishing Pharmacopœias or Dispensatories, in which a number of the most approved formulæ for the preparation and composition of medicines were accurately described, and were sanctioned either by the credit attached to the individual authors of them, or were enforced by the civil authority of the respective countries in which they appeared. It is not certainly ascertained what were the earliest productions of this description, but the first which acquired any considerable degree of reputation was that of Valerius Cordus, which was published at Nuremberg, in the year 1542. The first edition of the London Pharmacopœia was in 1637, and since this time most of the countries of Europe have had their own pharmacopœias, published under the authority of their respective governments. The dispensatories compiled by private individuals have been numerous, but in consequence of the various changes, and the great improvements that have taken place in pharmacy, most of them are now to be regarded chiefly as objects of curiosity, exhibiting a view of the state of the science at the time when they were composed. The Dispensatory of Dr. Duncan is the most modern, and must be considered as a very valuable collection of matter, which, in the successive editions that have appeared from time to time, has, in all respects, kept pace with the progress of knowledge.

The principal objects of pharmacy are, 1st, to preserve the substances employed from decay or accidental injury; 2d, to subject them to different operations, by which their virtues are concentrated, new properties are given to them, or they are, in some way or other, rendered more efficacious and commodious for practice; and, in the 3d place, after they have been properly prepared, to compound and mix them together in the most convenient form for the use of the patient. We shall pass over the first of these points, the preservation of the articles of the materia medica; the regulations that are laid down for this purpose, in the various practical works, are sufficiently obvious, and do not easily admit of being reduced to any general rules. On the next point, the preparation of the articles, we shall offer a few remarks, but before we do this, we must consider the subjects of pharmacy, not in relation to their effects upon the body, but to the sources from which they are procured, and their physical and chemical properties.

The substances that are employed in pharmacy are taken from each of the three kingdoms; the vegetable products are the most numerous, and the animal the least so. Of the vegetables occasionally the whole plant is used, but more generally some particular part of it only, some of its primary compounds, or some substance obtained from it by a mechanical or chemical process. Of the parts of plants, we employ the leaves, the stems, the roots, the flowers, the fruits, the seeds, the bark, or the wood: of the primary compounds, we employ gum, resin, fixed and volatile oils, (besides substances of an analogous nature, but which do not exactly fall under any of these denominations, as tragacanth, camphor, &c.) sugar, farina, tan, and extract, also the acids, alkalies, and neutral salts, which exist ready formed in vegetables. Among the substances that we procure from vegetables, but which did not previously exist in them, we may enumerate alcohol, under all its forms, æther, acetic acid, and a variety of inspissated juices, all of which seem to undergo some change, in their sensible and chemical properties, during the process of their preparation.

The pharmaceutical articles taken from the mineral kingdom are less numerous than those of vegetable origin, but many of them are substances of the greatest efficacy. The most important are the three mineral acids, the sulphuric, nitric, and muriatic; the various neutral salts formed from these acids, in combination with the alkalies and alkaline earths; some of the earths, both pure and united with acids; certain inflammable substances, of which the most important is sulphur; and, lastly, several of the metals, and the preparations formed from them. The articles employed in medicine that are derived from the animal kingdom are comparatively few in number; in the case of lytta, the whole animal is used, but in general it is some of the primary compounds, as lard, spermaceti, musk, wax, &c. and with a few exceptions, they are all employed as external applications.

The processes by which the various articles of the materia medica are prepared for the purposes of the prescriber are both mechanical and chemical. Among mechanical operations, we may mention trituration of all kinds, by which the particles of the substance are merely separated from each other; also the various means by which the substances are condensed, as simple pressure or desiccation; while, among the chemical processes, we may enumerate distillation, solution, precipitation, and crystallization. A particular description of all these operations, and the application of them to individual substances, does not belong to a general elementary treatise, and we must, therefore, refer our readers, for this kind of information, to the most approved pharmacopœias and dispensatories.

The 3d object of pharmacy, the compounding of medicines, is a branch of the art that has partaken very largely of the modern improvements that have been introduced into it. It may be considered under two points of view, either with respect to any change that is supposed to be produced in the medical properties of the substances that are united together, or simply in relation to the more convenient or eligible mode of their exhibition. It is generally admitted, that in some cases the combination of two medical agents produces an effect which does not belong to either of them singly, and which could not have been predicted from a knowledge of their separate qualities; a fact which is, in some measure, analogous to what we observe in chemistry, where the properties of the compound are often totally different from those of the ingredients. One of the most remarkable of these compounded operations in medicine is that of the union of an emetic with an opiate, by which the emetic and the narcotic effects of the substances in question are diminished, and a powerful sudorific is produced. In this case we have no reason to suppose that any change is wrought in the properties of the substances themselves, such as takes place when we unite an acid and an alkali, and form a neutral salt, but that the compound effect entirely depends upon the vital properties of the body on which it acts.

But, besides this kind of compound, where we actually form a new medical agent, there are many instances in which we combine two substances together, for the purpose of obtaining their conjoined effect; thus we often prescribe a bitter in conjunction with an aromatic, where the operation of each of the ingredients not only remains unaltered, but where they mutually assist each other. There are other cases in which we attempt to accomplish two objects at the same time, which, although not precisely similar, still, however, they both conspire to the same end; as when we give a stimulant along with a tonic, in order that the action of the latter upon the digestive organs may enable them to retain the former, which otherwise they might be disposed to reject. In the same manner, we occasionally give an opiate along with a mercurial, when we wish to prevent the latter from operating as a purgative, and are desirous of promoting its constitutional effect. These additional agents have been styled, in technical language, adjuvants and corrigents, and, to a certain extent, there is a real foundation for these terms. This assisting and correcting plan was, however, carried to a most unreasonable and ridiculous extent by the older practitioners, and the consequence was, that they were induced to form a multifarious mass of substances, in which there can be no doubt that the virtues of the active ingredients were materially impaired, and sometimes it is probable that the compound acquired new properties which were not in the contemplation of the prescriber. Without going back to the complicated formulæ of the Galenists after the revival of letters, we need only refer to those of the London college about a century ago. In the edition of their pharmacopœia, which was published in the year 1720, under the presidency of the eminent naturalist Sloane, and at a period when philosophical knowledge of all kinds had made such considerable advances, we find, that most of the old complicated remedies were still retained, affording a very decisive proof of the imperfect state of medical science, and at the same time constituting a very powerful obstacle to its improvement.

The compounding of medicines, so far as it respects the mere form in which they are exhibited, is a department of the art, less important, indeed, than that which respects their action on the living body, but one which is not to be disregarded. The ultimate effect of remedies is not unfrequently counteracted by their immediate operation upon the stomach, if they are given in such a form as to excite nausea, or any unpleasant sensations of disgust; and, independent of this circumstance, the virtue of the agents themselves may be materially affected by the mode in which they are prepared. The forms of medicines must vary, partly from the nature of the substance as to its sensible properties, and partly from the use to which it is to be applied. In the complicated pharmacy which formerly prevailed, we have various kinds of recipes which are now entirely exploded, and for which it would be difficult to assign any object but that of designedly adding to the labour of the apothecary. No one contributed more to simplify the compounding of medicines than Gaubius, who placed the subject upon a rational and scientific basis, and actually produced a considerable reform, which has been still farther advanced by his successors. A large share of the old pharmacy is still, indeed, retained in some of the other countries of Europe, but in England, it may be asserted, that we have very few, if any formulæ in use, which are not rendered necessary by the nature of the substances employed, or recommended by their obvious utility. For the description of all these different articles, the mixtures, powders, pills, &c.—for the best method of preparing them—and for the several purposes to which they are particularly applicable, we must again refer to the modern pharmacopœias and dispensatories, and especially to that of Dr. Duncan.

Along with the other changes which have taken place in pharmacy, we must not omit to notice that which has been made by the colleges of London and Edinburgh in nomenclature. In consequence of the great advances that had been effected during the last half century in chemistry and natural history, it was found that a large proportion of the names employed in pharmacy were either obsolete or incorrect; it was therefore thought desirable to discard them, and to substitute in their room the appellations which seemed to be sanctioned by the latest scientific discoveries. The actual result has not been so successful as might have been expected; for although the two pharmacopœias were published within a short time of each other, yet a great proportion of the terms that they respectively employ to designate the same substances are different. This difference arises, partly from the colleges finding it impossible strictly to adhere to the rules that they proposed, without rendering the names most inconveniently long and cumbersome, and partly from the rapidly progressive state of the sciences of chemistry and natural history, by which, even in the course of a very few years, the aspect of the former has been materially changed, and the boundaries of the latter greatly extended,—the result of which, in each case, has been a radical alteration of nomenclature. Besides, it happens that many of the articles that are the most efficacious in medicine, are either of uncertain origin when derived from the vegetable kingdom, or of doubtful composition when formed by chemical processes. It would appear, therefore, that the state of the science of materia medica is not yet sufficiently advanced for the radical reform which the British colleges attempted to accomplish.

The following list contains most of the principal authors on the Materia Medica in modern times, who either contributed in any considerable degree to advance the science, or whose works were held in estimation by their contemporaries. Essays or treatises on particular substances, or on individual articles of the materia medica, are not included in this list.

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Hahnemann, *De Viribus Medicaminum*, 1805.

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Schlegel, *Thesaurus Materiæ Medicæ*, 1793-7.

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Swediaur, *Materia Medica*, 1800.
Venel, *Precis de Matiere Medicale.*
Vogel, *Historia Materiæ Medicæ*, 1774.
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Young's *Medical Literature*, 1813. (*a*)

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MATHEMATICS.

Mathematics is the science which has for its object the abstract relations of number and magnitude, and their application, through the medium of observed laws, to the useful purposes of life, and the explanation of natural phenomena.

From this description it follows, that mathematical science naturally divides itself into two principal branches: The one, resting solely on our intuitive perceptions of abstract truth, and demanding no assistance from inductive observation, and very little from the evidence of our senses, constitutes the *pure mathematics*, and comprehends all inquiries into the relations of magnitude in the abstract, and the properties of extension; the other, taking for granted the truth of general laws deduced by legitimate induction from observations sufficiently numerous, supplies the hidden links which connect the cause with its remote effect, and endeavours from the intensity of the one to estimate the magnitude of the other. To this branch of the mathematics the epithet *mixed* is in consequence applied.

It might be imagined, from the distinction here taken, that the evidence on which these two great branches of science rest, and the certainty of their conclusions, differ essentially in kind as well as degree. The former enjoys confessedly the highest rank in the scale of human knowledge, its object lying amongst the most simple, the most distinct, and best defined of our notions; while its reasoning consists of successive decisions of judgment, in each of which the objects to be compared are brought before the mind with such perfect clearness as to render mistake impossible. Analogy, or likeness, that grand source of human error, is excluded from a science in which absolute equality or inequality in respect of magnitude is the only point which ever comes in question; while the practice of mathematicians in defining strictly every term, and adhering rigorously to their definition in its employment, cuts off every possibility of mistake from inaccuracy of language; and their extreme caution in dwelling upon and analysing each successive step of their reasoning, saves them from the dangers of precipitancy: the latter, on the contrary, will participate in the uncertainty which must always hang about the inductive process, however far it may be pushed, since every conclusion which rests ultimately on the basis of observation must be infected with all the errors to which human observations, however carefully made, and however often repeated, are liable. This would certainly be a correct view of the subject, were it not that (such is the nature of mathematical reasoning) the errors so induced, like the impurities fabled to have mixed themselves with the sacred river of antiquity, may be kept distinctly in view through the whole train of reasoning, and their effect on the results correctly estimated and separated at its conclusion.

The defects in principle, arising from the acknowledged imperfection of human observation, may be reduced to two classes. The first originates from overhasty generalization, or assuming laws to hold universally which have only been verified by partial experience. This is, in fact, reasoning from imperfect analogies, and without the whole state of the case before us, and, in its effect on our conclusions, is equivalent to a total ignorance of principles in all cases which form exceptions to the laws. But this once fertile source of false philosophy can hold no place in mathematical reasoning, which invariably makes a reserve in favour of ulterior observation, and whose pretensions are confined to the deduction of right conclusions from right principles. The other class of defects which may vitiate our fundamental principles, arises from a want of perfect accuracy in the observations employed to establish them, whereby some of the elements of calculation are, as it were, distorted from their true value. But neither can these affect that part of our train of reasoning which is strictly mathematical, the same reservation which is made in favour of the observed laws being extended to the precision with which they are stated. But here we may go farther, and this it is which renders the application of mathematical reasoning to natural science useful and satisfactory, even admitting the existence of unavoidable error in the connecting link. It is always in the power of the observer to assign limits, beyond which the errors of observation cannot possibly extend, which will be narrower in proportion to the simplicity of the observations themselves, and the care with which they are made. Now, it is capable of demonstration, that, in proportion as these limits are narrowed, the extent of the error induced on the result will experience a corresponding diminution, and, in the application of mathematical calculation, it is always practicable to include such errors of observation in the expressions of physical laws, and thus to determine the maximum of their influence; so that, although the imperfection of our means of observation will not permit us to fix the precise point where truth resides, we are still enabled to say, with perfect certainty, that between such and such limits it must be found. Happily, in all the great problems of nature to which mathematics have been hitherto applied, and which most interest mankind, these limits are so contracted as to reduce the conclusions to a kind of practical certainty, not inferior to that on which we act with full confidence in the most important affairs. But however this may be, the speculative certainty of conclusions in the mixed mathematics remains unimpaired. The geometer who reasons on the comparative weights of a globe of brass and a cube of water, is perfectly indifferent whether, in any particular globe presented to his view, the microscope may not discover superficial irregularities, or whether the instruments used for taking specific gravities be susceptible of mathematical precision. He reasons on them as creatures of his own imagination, agreeing in their forms and qualities with certain arbitrary definitions, and is fully aware that, in so far as bodies are to be found in nature which conform to those definitions, in so far only will his conclusions apply to them.

The mixed mathematics are, therefore, primarily dependent on the extent and accuracy of our scrutiny into nature; after which, their farther advancement is limited only by the degree of perfection to which the pure are carried. But to a very moderate progress in the former, a very perfect knowledge of the latter is requisite. The laws of nature, indeed, are for the most part simple in themselves, but the circumstances under which they act induce a complication in their agencies, which calls at once for the most powerful exertions of natural reason, and the most refined artifices of practised ingenuity to develope. Combinations are perpetually presenting themselves where the principles are satisfactorily known—the general laws placed beyond a doubt—the mode of applying mathematical investigation thoroughly understood—yet which, by the mere complication of the pure mathematical inquiries they involve, defy the utmost powers of calculation. The restless activity of Nature surrounds us with minute phenomena of this kind. The motions and equilibrium of fluids—their capillary attraction—the vibrations of the atmosphere and of solid bodies—every breath of wind that blows, and every mote that sparkles in the sunbeam, supplies us with an instance in point. On a wider scale, the simple law of gravitation, modified by the consideration of three gravitating bodies in motion, produces a problem which has resisted every effort of ingenuity and industry, stimulated by the strongest motives which can rouse man to exertion. This consideration will afford an ample answer to those who look on abstract inquiries, which have no immediate practical object in view, as useless or contemptible. The luxuriance of modern analytical speculation is arrived at such a point as to startle the most industrious, and to render an equally perfect knowledge of all its parts no longer attainable by one individual; yet of all the ingenuity which has been lavished upon the system, of all the lives drawn out in abstract speculation, no portion can, with a shadow of reason, be looked upon as waste labour, so long as we remain uncertain whether the very next physical problem which presents itself for examination, may not plunge us at once in the most remote and obscure of its recesses.

The history of mathematical science may be advantageously divided into three great periods, in each of which new methods have arisen, and very important alterations in the mode of considering questions taken place. The first comprehends the ages in which the ancient geometrical methods were almost exclusively cultivated, whose characterising feature consists in the use of properties of extension, through the medium of artificial representations or diagrams, not merely to investigate the relations of figures to one another, but, by the help of certain observed analogies, to demonstrate the properties of magnitude in the abstract, (as in some propositions in the 2d book of Euclid.) The second period commences with the presumed origin of the algebraic calculus, as far as it can be traced among the Hindoos, and comprehends its importation into Europe through the medium of the Arabs—its first application to Geometry, and the consequent changes which took place in the mode of conceiving mathematical questions. This may be regarded as a kind of *transition* state of the science, the advantage of the new methods being felt, but symbolic analysis, though reinforced by the fluxionary or differential calculus, not having yet attained sufficient maturity to take the whole burden of investigation on itself. At first, indeed, the algebraic investigation of a problem was merely regarded as a preparatory process, afterwards to be exchanged for a geometrical construction and synthetic proof. By degrees, the symbolic investigation was admitted to the higher rank of an integrant part of the process, and, towards the end of the period we are speaking of, so far took the lead, as to have in a great measure supplanted the use of diagrams as a medium of demonstration. This change is easily explained. Among the ancient philosophers, whose delight was in reasoning, and who troubled themselves but little with any thing else, geometry, while it attained a degree of elegance scarcely to be surpassed, had assumed a form singularly unfavourable to useful applications, where results are to be actually computed, and approximations made. For these purposes the most exquisite geometrical construction is often but the mockery of a solution. But even its elegance was speedily found to desert it, when tried upon the more difficult inquiries of the modern philosophy, while its application to such researches was attended with a degree of intellectual exertion, a contention of mind sufficient to deter the boldest reasoner from its use. It is not then to be wondered at, that the facilities afforded by the algebraic methods should lead to their gradual adoption, especially when they were found, on cultivation, to assume a degree of elegance not inferior to those whose place they supplied, and infinitely to surpass them in force and extent. The last and greatest revolution of mathematical science was rapidly approaching, when symbolic language, found adequate to every purpose, became the universal medium of mathematical inquiry, and when those extraneous notions, which, during the foregoing period, had insinuated themselves into its principles, were purged away. This brings up its history to its present state, which (if it be allowed to humanity to speculate on the future destinies of science) seems placed beyond the reach of further revolutions, and secured from change, unless by some political convulsion capable of submerging at once the gathered knowledge of ages. We may go farther: We may predict, that, in the event of such a catastrophe, the revival of mathematical science would exhibit in its great features the same succession of changes it has already undergone, and sooner or later must inevitably terminate in the same system.

In a work like the present, where absolute unity of design and execution is unattainable, the semblance of it may be sacrificed, on some occasions, to secure the more solid advantage of consulting brevity, and avoiding repetitions. The history of the first age of mathematical science has already been given at some length, under the article Geometry, to which we therefore, without hesitation, refer our readers for an account of its successive steps and chronology, confining ourselves in this place to a few observations on its general methods, which the wider views afforded by the algebraic system irresistibly suggest.

Previous to the invention of the geometrical analysis, the solution of a problem was undertaken by no regular process. The tact acquired by practice, and such natural penetration as the geometer might possess, were all he had to depend upon in constructing his figure, and combining his data. This analysis is so far a regular system, that, in a general way, setting out from the data of the question, it derives from them a set of necessary consequences, which, becoming in their turn data, give rise to another set of conclusions, and so on, till at length, by more or fewer intermediate steps, we arrive at one which obviously includes in it the solution of the question. But the essential difference between it and the synthetic method is this—that however careful we may be in representing all our magnitudes by lines, angles, &c. and however cautious in rejecting all but geometrical expressions from our language, and all but geometrical considerations from our reasoning, still, till the solution is discovered, the component parts of our diagrams (such only excepted as represent data) are to all intents and purposes arbitrary symbols—true hyeroglyphics, having no more real relation to the magnitudes they represent, than the unknown symbols of an algebraic equation. Indeed, the geometrical and algebraic analysis are, in this respect, exactly on a par; and if we think that any accession of distinctness is here to be gained by graphical representation, we deceive ourselves, and offend against the essential nature of all analysis. This will appear more sensibly, when we reflect, that in a complex problem, some of the data may involve an *unperceived* contradiction: all our constructions will thus be impossible, and the lines, angles, &c. on which we have been reasoning, can in no way have been *real pictures* of what they are supposed to represent. Yet we go reasoning on without regard to this, till at some more or less remote step the contradiction strikes us. It does not then at all follow, because we construct diagrams, and represent magnitudes by lines, &c. that *therefore* we are conversant only with realities. This is only the case when, having arrived at a real conclusion by the intervention of arbitrary symbols, (be they lines or letters,) we retrace our steps in synthetic order. The very same may be said of the most abstract algebraic investigation.

The general principle of the geometric analysis is then identical with that of the algebraic, and of any yet more extensive analytical system which may in future be devised. Let us now examine the use the ancients made of it. Every system must have its peculiar rules and processes; and it is obvious, that without some regular guide in the analysis of a problem, it might require as much of the inventive faculty to strike at once into the train of consequences which leads direct to the point in question, as to discover the solution by a single effort. It is this reduction to a regular process, which constitutes the chief merit of the method of loci. By it, the the geometer is placed in the path he is to follow, with a certainty of arriving at his end, provided he can overcome certain difficulties which may lie in his way. He is directed (see Locus, and GEOMETRY) to turn his attention towards ascertaining the nature and situation of two or more curves traced out by certain points in his figure, under certain conditions of variation in the construction; and if he can accomplish this, his problem is resolved, as far as geometry is capable of resolving it, though with more or less neatness, in proportion to his ingenuity. This invention places the ancient analysis still more nearly on the same footing with the modern methods. The discovery of two curves is the same with the deduction of two equations between as many unknown quantities. The determination of their intersection is identical with the elimination of one unknown quantity and the resolution of the resulting equation. So far the parallel is close; but the unwieldiness of the ancient processes, the immense length of their demonstrations, and the unnecessary complication of their theory of ratios, cramped their efforts, and confined the application of their method of loci within very narrow limits. After all their endeavours, it was still far from that degree of perfection, which infallibly leads to the solution when within the reach of geometrical construction, or as infallibly demonstrates its impracticability in the contrary case, and is therefore, setting aside all considerations of convenience, decidedly inferior to the modern algebraic system. No regular process was known to the ancient geometers for determining the nature of their loci. They might be circles or parabolas, conchoids or spirals, but, unless some case of ease, some peculiar combination of data, or penetration in the geometer himself suggested their nature, the difficulty was only shifted, not overcome. He possessed no certain method for determining this essential point—no infallible process for recognising the curves he was employing. In fact, this was the very difficulty which arrested the ancients, as we find in the celebrated problem "ad tres aut plures lineas," mentioned by Pappus, which proposes to find the nature of a curve formed by the continual meeting of certain lines. In the most simple cases, Euclid and Apollonius had shewn it to be a conic section; but beyond this the ancients never could advance, and it was reserved for the first application of the algebraic method by Descartes to accomplish the solution in all its generality.

To render mathematical speculations of any real use, the numerical solution of problems is indispensable; and in this, we have every reason to conclude, the ancients were much behind. The want of a convenient arithmetic impeded them greatly in actual calculation, and even obliged them to have recourse to a certain mechanical contrivance, called the Abacus, as we now see the Chinese use their swan-pan, and the inhabitants of Mexico their knotted strings. Indeed, the whole character of their geometry abundantly shews, that the rule and compass were actually resorted to in practice; that they employed their constructions, not as modern geometers have done, merely to explain the theory, and deduce *rules* of computation, but to perform the computations themselves, and give by measurement the length of lines and magnitude of angles. This, though a most rude and troublesome method, might suffice in the more ordinary practical cases; but when the purposes of a more exact astronomy demanded greater nicety, they would find themselves much embarrassed. The construction of solid figures is next to impossible; and we may reasonably surmise, that the first essays of Hipparchus towards a system of trigonometry, consisted in the demonstration of such properties of solid angles and their including planes, as would enable him to reduce the usual astronomical computations to the construction of plane triangles; and this again to its most simple case, the right angled triangle, or in point of ultimate difficulty, to the determination of an arc from its chord, and *vice versa*. Here we think it exceedingly probable that graphical estimations, founded on some mechanical contrivance, might be resorted to. Archimides, indeed, by his quadrature of the circle, (the first example of the approximate solution of a difficult problem which deserves the name,) had afforded a basis on which a tolerably exact table of chords might have been constructed, his inferior limit differing from the truth only in the fifth decimal, yet there is a difficulty how the ancients could apply this to any useful purpose, without a farther insight into the artifices of computation than we have any reason to suppose they possessed. The employment of chords, as being more directly and accurately measurable than any other lines in a circle, seems to corroborate this surmise of a mechanical estimation. The remaining fragments of the two first books of Pappus suffice at least to shew, how inconceivably embarrassing their arithmetical computations must have been.

We shall now take up the history of our subject from that distressing period in the annals of mankind, when the decline of intellectual vigour kept pace with the downfal of the Roman power, and a race of commentators, few in number, and each more feeble than his predecessor, alone remained, the diminutive representatives of those giants in literature and philosophy who graced a happier age. The sciences, which yet lingered among the wrecks of the eastern empire, at length took refuge from neglect and returning barbarism in the bosom of the Arab conquerors. The Caliph Almamon, the seventh of the Abbassides, collected with zeal the monuments of Grecian science, caused them to be translated into Arabic by the most skilful interpreters, and earnestly exhorted his subjects to their perusal. The exhortations of an absolute sovereign, supported by his personal example, rarely fail of their end; and many respectable astronomers and mathematicians soon arose among them. Yet the Arabic philosophers, though learned, were not inventive, and during this temporary sojourn (from the 8th to the 15th century) mathematical science has little real progress to boast. With the first dawn of reviving literature in Europe, the precious deposit was reclaimed, and re-translations from their versions imperfectly supplied many works of which Greek copies could no longer be discovered. The books of Apollonius, after the fourth, (with the exception of the eighth, which seems irrecoverably lost) are among this number.

From the 13th, to the end of the 15th, or middle of the 16th century, the learned were busied in recovering the knowledge of geometry, and placing themselves on a level with the state of science which preceded them. The fall of Constantinople in 1453, while it spread dismay throughout Europe, scattered at the same time into every nation fugitives, who carried with them, in their native tongue, the key to the treasures of antiquity. From this time, a knowledge of the Greek language became common in the West, and the Greek geometers were once more read, translated, and commented on. We must, however, pass over the detail of the recovery and restoration of the ancient authors, to enter on the wider field which the introduction of algebra into Italy begins now to present.

So early as the latter part of the 10th century, (A. D. 980) Gerbert, having learned of the Moors in Spain their system of arithmetic, had imparted it to his countrymen the French, whence it rapidly spread over Europe, and continues in use to the present moment. The Moors and Arabs, by their own unanimous avowal, derived this admirable invention from the Indians, who, there is good reason to believe, were in possession of it, at least from the time of Pythagoras. The story of this philosopher's visit to the Brahmins is well known, and a suspicion may be entertained, that his time there was better employed than in picking up the ridiculous doctrine of the transmigration of souls. Boetius relates the singular fact, of a system of arithmetical characters and numeration employed among the Pythagoreans, which he transcribes, and which bears a striking resemblance, almost amounting to identity, with those now in use, whose origin we know to be Indian. The discovery (generally so considered) of the property of the right angled triangle by the same philosopher, is a remarkable coincidence. This was known ten centuries before to the Chinese, if we may credit the respectable testimony of Gaubil: It was well known to the earliest Indian writers of whom we have any knowledge, and who appear to have derived it from a source of much more remote antiquity. It is scarce conceivable that a *Greek* invention, of such extreme convenience as the decimal arithmetic, should have been treated with such neglect, remaining confined to the knowledge of a few speculative men, till, from being communicated as a mystery, it was at last preserved but as a curiosity; but the aversion of that people to foreign habits will easily account for this, on the supposition of its Indian origin. An abstract truth, however, is of no country, and would be received with rapture, from whatever quarter, by men already advanced enough to appreciate its value. We are then strongly inclined to conclude, that in the latter, as well as in the former instance, Pythagoras may have acted only the part of a faithful reporter of foreign knowledge, though the reverse hypothesis, viz. that the first impulse was given to Indian science at this period by the Greek philosopher, might certainly be maintained. However this may be, the great question as to the origin of algebra, which has been the cause of so much speculation, seems at length, by the enlightened researches which have of late been made in Indian literature, nearly decided in favour of that nation. It will be proper to state, as briefly as is consistent with perspicuity, the grounds of this conclusion. The earliest Indian writer on algebra, of whom any certain, or even traditional knowledge has reached us, is the astronomer Aryabhatta, who, from various circumstances, is concluded to have written so early as the fifth century. It is true, the work of Diophantus takes the precedence of this in point of antiquity by about 100 years, nor is it at all intended to deprive the Greek author of the merit of independent invention. Indeed, the comparison of the state of knowledge in the two countries at the periods we speak of, is decidedly favourable to the independence of their views. By what we know of the Indian author, it appears that he was in possession of a general artifice of a very refined description (called in Sanscrit the *cuttaca*, or *pulveriser*,) for the resolution of all indeterminate problems of the first degree, and also of the method of resolving equations with several unknown quantities. It is very unlikely that these methods should have arisen at once, or been the work of one man, especially as they are delivered incidentally in a work on astronomy. Now, of the latter of them we are not sure that Diophantus had any knowledge, as, although he resolves questions with more than one condition, he always contrives, by some ingenious substitution, to avoid this difficulty: Of the former he was certainly ignorant. His arithmetic, indeed, though full of ingenious artifices for treating particular problems, yet lays down no *general methods* whatever, and indicates a state of knowledge so far inferior to that of the Indian writer, that no supposed communication with India about the third or fourth century would at all account for the phenomena. But there is yet stronger evidence. The Brahma-sidd'hanta, the work of Brahmegupta, an Indian astronomer at the beginning of the seventh century, contains a general method for the resolution of indeterminate problems of the second degree; an investigation which actually baffled the skill of every modern analyst till the time of La Grange's solution, not excepting the all-inventive Euler himself. This is matter of a deeper dye. The Greeks cannot for a moment be thought of as the *authors* of this capital discovery; and centuries of patient thought, and many successive efforts of invention, must have prepared the way to it in the country where it did originate. It marks the maturity and vigour of mathematical knowledge, while the very work of Brahmegupta, in which it is delivered, contains internal evidence, that in his time geometry at least was on the decline. For example, he mentions several properties of quadrilaterals as general, which are only true of quadrilaterals inscribed in a circle. The discoverer of these properties (which are of considerable difficulty) could not have been ignorant of this limitation, which enters as an essential element in their demonstration*. Brahmegupta, then, in this instance retailed, without fully comprehending the knowledge of his predecessors. When the stationary character of Hindu intellect is taken into the account, we shall see reason to conclude, that all we now possess of Indian science is but part of a system, perhaps of much greater extent, which existed at a very remote period, even antecedent to the earliest dawn of science among the Greeks, and might authorise as well the visits of sages as the curiosity of conquerors.

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* This argument has been overlooked by the author of the two able articles on Hindu algebra, in the 42d and 57th Numbers of the *Edinburgh Review*. It is of particular force in one instance—the elegant property discovered by Ptolemy and annexed at the end of the 6th book of Simson's edition of Euclid.

The dates assigned to the writings of the two philosophers here mentioned, are sufficient to exclude the Arabs from any claim to the invention of algebra. Indeed, they can scarcely be said to advance any, nor was it ever carried to any degree of perfection among them. Many circumstances render it not unlikely, that the Arabic algebra was principally borrowed from the Greeks, assisted perhaps by occasional communications with Hindostan. At the time of its transmission into Europe, it consisted merely of rules for the raising of quantities to powers, and the resolution of simple and quadratic equations. The Indian algebra possessed a very tolerable symbolic notation, while the Arabic was entirely destitute of any such assistance, approaching in this respect much more nearly to that of Diophantus, which can scarcely be said to employ symbols in a systematic way. In this state it was found by Camillus Leonard of Pisa, in his travels in the East early in the 15th century, and brought by him (if not before) into Italy, and about the middle of this century had become pretty widely diffused over Europe. The first printed work on algebra is that of Lucas Pacioli de Burgo, in 1494, which exhibits the art nearly in the rude form we have described it, and with little improvement in respect of notation. Indeed, the notation of the earlier algebraists consisted merely in abbreviations of Italian words, as *p* for *piu*, or plus; *m* for *meno*, or minus; *co* for *cosa*, the *thing*, or unknown quantity, &c. Our present notation has arisen by almost insensible degrees, as convenience suggested different marks of abbreviation to different authors, and that perfect symbolic language which addresses itself solely to the eye, and enables us to take in at a glance the most complicated relations of quantity, is the result of a series of small improvements, made from time to time, some of which have even been forgotten and re-invented; while in no case, at least till within a very short time from the present period, has any general and systematic view of the nature of symbols directed the choice of new ones.

Algebra had not been long known in Italy before important discoveries were made in it. The resolution of equations, naturally the first object to which the attention of its cultivators was directed, speedily reached a point beyond which it has never yet advanced. Scipio Ferrea, in 1505, was the first to discover the solution of a cubic. It was the practice of the geometers of those days, and for two centuries afterwards, to conceal their discoveries, in order to secure by that means an advantage over their rivals in proposing problems beyond their reach. It is chiefly owing to this, that such innumerable disputes have arisen respecting the claims of independent inventors. The charge of plagiarism was always at hand, to conceal the chagrin, and south the vanity of an author, whose expectations of humbling his opponent were disappointed by some unlooked for exertion of inventive genius; or, if actuated by nobler motives, he could acquiesce in the well earned fame of a rival, the malignity of inferior writers, masking itself in the more specious semblance of national partiality, was ever ready to prefer the charge in its most aggravated and disgusting form. Tartalea, a man of low origin, but extraordinary powers, to whom some problems turning on this discovery of Ferrea had been proposed in defiance, set himself to discover the solution, in which having succeeded, he shortly after revealed it in confidence to Cardan, after binding him to secrecy by the most solemn oaths. Cardan, however, made no scruple immediately to reveal it, and even on the strength of a demonstration, and some extensions of it, (as they were then regarded,) to claim it as his own. A violent dispute took place, accompanied with mutual challenges to a trial of skill, and endless were the problems proposed and resolved on both sides. The dispute, though productive of nothing but chagrin and heart-burnings to the parties, yet ended in the permanent improvement of science. Louis Ferrari, a quandam pupil of Cardan, was called in to prop the tottering reputation of his master, and the first exploit of this new combatant was the general resolution of the biquadratic equation by a very elegant process. This discussion too contributed much to a better understanding of the properties of Surds. To Cardan, however, algebra is much indebted, the idea of denoting general or indefinite quantities by letters of the alphabet, being strictly speaking his due, though employed nearly about the same time by Stiefel, a German, and extended and rendered an essential part of algebra by Vieta, in 1600. Cardan also noticed the negative roots of equations, which he called fictitious, and observed the difficulty of the irreducible case of the cubic, which, like the quadrature of the circle, has since so much tormented the perverse ingenuity of mathematicians. Not that he understood its nature. It was reserved for Bombelli, an algebraist, who wrote in 1579, to demonstrate the reality of the apparently imaginary expression which the root assumes in that case, and thus to lay the foundation of a more intimate knowledge of imaginary quantities.

The cubic and biquadratic equations having yielded as it were to the first attack, it is not surprising that the general theory of equations should soon be entered upon. The first steps were made by Vieta, whose work, full of ingenuity and original views, appeared in 1600. In this, the composition of the co-efficients of equations in terms of their roots (supposed, real and positive,) is fully pointed out, a discovery which may be regarded as the germ of those more general views which Harriott afterwards took of the same subject. Some other discoveries of Vieta will be noticed hereafter.

The multiplicity of the roots of equations had been early recognised, and, as we have seen, the negative ones had not been overlooked. The imaginary ones, however, though they could not have altogether escaped notice, were disregarded as useless, if not absurd. The first general views on this subject are those of Albert Girard, a Fleming, much less celebrated as a mathematician than he deserves, partly on account of his antiquated style and notation, and partly being eclipsed by the superior fame of our countryman Harriott, whose views are, however, in many respects less profound than those of Girard. The "nouvelle invention en algebre" of the latter, (1629,) extends Vieta's composition of the co-efficients of an equation to the case of negative and imaginary roots, first notices the *fact* that an equation has as many roots, of one or the other species, as dimensions, and which is a proof of his intimate acquaintance with their theory, first shews how to express the sums of their powers, in terms of the co-efficients, (for which Newton long afterwards gave a well known and compendious rule of continuation, and Waring exhibited the general expression.) It only remained for Harriot to bring the whole theory of equations under one simple and comprehensive point of view, by his capital discovery of the composition of polynomials by the multiplication of simple factors. His "Artis Analyticæ praxis," in which this discovery is contained, appeared long after his death, in 1631. Of course it was written before Girard's work; but those who will not be at the pains to make their discoveries public, cannot complain if the general progress of knowledge should raise up some one to anticipate a part of their views. The remaining improvements in the theory of equations we shall defer noticing till we approach nearer to the present time, and come to take a general view of the present state of analytical science.

Meanwhile, the effect of these improvements in algebra began to be sensibly felt in every branch of the mathematics, but the pure geometry was the first to rise above the state in which the ancients had left it. Our countryman Oughtred is usually considered the first who applied algebra to geometry, so as to discover new properties. Vieta had, however, before demonstrated, by algebraic processes, a great number of properties of the chords of multiple arcs, which form to this day a very important part of the theory of angular sections. The use of the negative roots of equations in the solution of geometrical problems was clearly pointed out by Girard, though Montucla has, (in express contradiction of his own words, when speaking of that geometer,) attributed it positively to Descartes. The latter, however, has claim enough on the admiration and gratitude of mathematicians, in his method of representing the characterising property of a curve by an equation between two variable magnitudes. This great step, which brought at once the whole of geometry under the dominion of symbolic analysis, was made in his *Geometry*, published in 1637. The revolution so produced in the way of conceiving geometrical questions, can be compared to nothing but that which the invention of Loci produced in the ancient methods. The comprehensive genius of Descartes immediately felt the whole force of his discovery, and hastened to apply it to problems then regarded as of the greatest difficulty and generality, among which were the methods of drawing tangents to all sorts of curves, and the general theory of maxima and minima. As we now approach to the momentous era of the discovery of the differential calculus, it will be proper to take a view of the preparatory steps which led to this great invention.

The discoveries of Archimedes were delivered in too abstruse a form to be generally understood, or much pursued, and a very long interval elapsed without adding any thing of consequence to them. At length Pappus, by demonstrating the elegant property of the centre of gravity of a plane figure, by which the solid formed by its revolution may be measured, showed the practicability of advancing farther, and even in some measure anticipated the discoveries and the method of Cavaleri. But Pappus fell on evil times.. A decaying empire, and a degraded people, furnished no successor who might catch the blaze of science before its final extinction. The Arabic geometers never arrived at this point, much less advanced beyond it.

Early in the 17th century, Lucas Valerius, and the celebrated Kepler, had made some advances beyond those of Archimedes, in the theory of centers of gravity and the dimensions of solids. The researches of Kepler, although not very profound, first, however, familiarized geometers with the use of the term infinity. Even his failure in the solution of some of the more difficult of the problems he proposed aroused curiosity, more perhaps than success would have done, and incited others to similar inquiries. Cavaleri, professor of astronomy in Bologna, following in the same path, published in 1647 his Method of Indivisibles. In this he regarded a line as composed of an infinite number of points, a surface of an infinite number of lines, and a solid of surfaces, which are as it were the last elements or ultimate particles beyond which division could not be conceived carried. The objections against this method, on the score of metaphysical correctness, were in a great measure removed by Pascal, who, instead of points, lines, and ſurfaces, substituted infinitely short lines, infinitely narrow parallelograms, and infinitely thin solids, thus reducing it to the method of infinitesimals. It is scarce conceivable, however, that this was not the light in which Cavaleri himself saw the principles of his method, but exhibited it in this form, in order to avoid, or rather slur over the difficulties which might arise in verifying a limit according to the ancient method of exhaustions. Instead of shewing, for instance, that the set of infinitely small triangles, included between the arc of a curve and its inscribed parallelograms, may be safely neglected, as bearing no proportion to the latter, he leaves them altogether out of consideration, thus avoiding any discussion on the subject; a ready way, it must be confessed, of shortening demonstration. The capital advantage arising from this method, is the hold it affords to the application of algebra to determine the areas, &c. of curves. Its influence in this respect, on the progress of the new methods, we shall soon have occasion to speak of.

About the same time that Cavaleri was making these momentous discoveries in Italy, (for such they were in the event, however carelessly exhibited,) Pascal, Personnier de Roberval, Fermat, and Descartes, in France, were advancing rapidly towards that point where the want of some such calculus as the differential began to be felt. Roberval, by an attentive perusal of the writings of Archimedes, arrived (about 1644, as he assures Torricelli, in a letter to that philosopher,) at a general method of resolving problems relating to curvilinear areas, which was afterwards published in his treatise on indivisibles; not, however, till after the publication of Cavaleri's work, which turns on the same principles, and it ought to be remembered, too, that the latter geometer was 20 years in possession of his method before it saw the light. The problems of tangents and maxima and minima, as we have already noticed, were resolved by Descartes; but his method, (founded on the equality of two roots in the equation of a curve, which takes place when the ordinate becomes a tangent, and the parallelism of the tangent to the abscissa, when a maximum or minimum,) though ingenious, general, and easy, is yet not calculated to lead to any views immediately pointing to the differential calculus. The methods proposed by Roberval and Fermat tended, however, directly to this point. That of Roberval is founded on the theory of compound motion. The describing point of a curve is supposed animated with two motions, in consequence of whose composition it moves every instant in the direction of a tangent. The method of fluxions, had any such then existed, would have shown him how the relative velocities of these motions, and in consequence the position of the tangent, might have been in all cases determined. In fact, this idea of Roberval is to this day the connecting link by which the problem of tangents is subjected to analysis in treatises of fluxions (Simpson's *Fluxions*, i. 52) But Roberval possessed no means of determining these velocities; and, accordingly, except in a few cases (as in the conic sections) where they present themselves obviously, his method remained barren in his hands. Fermat's methods of tangents and maxima, it cannot be denied, are precisely those which the differential calculus, founded on the theory of developements, employs as the medium of its application to these problems. In his method of maxima and minima, for instance, in the function which is to become a maximum, he substitutes for the independent variable x, the same increased by a certain quantity e; and as the condition of the maximum requires, that when e is infinitely diminished, or zero, these two expressions should be equal, he equates them, clears the equation of surds and radicals, and, striking out the common terms, the whole becomes divisible by e, *after* which e is made zero, and the equation of the maximum obtained. The principle of his method of tangents is exactly similar. It must be allowed, that these are precisely the processes, at least in point of principle, which connect the theory of maxima and tangents with the purely analytical method of exhibiting the differential calculus.

We have been thus particular in stating Fermat's method, because it is upon the strength of this that La Grange, in a work which will for ever command the admiration of geometers, lays it down as a necessary consequence, that "on peut regarder Fermat comme le premier inventeur des nouveaux calculs;" while La Place, yet more decisive, assures us,* that "Il parait que Fermat, *le veritable inventeur du calcul differentiel*, l'ait envisagé comme un cas particulier de celui des differences," &c. We would willingly have been spared the task of disputing his claim to that splendid title against such authority: and we trust that in so doing we shall never forget that deference which the names of La Grange and La Place are entitled to claim, or that in the mass of mathematical history which the former has taken such pains to elucidate, no less by his astonishing learning than by the profoundness of his views, this instance of partiality to a countryman stands absolutely single.

One might be led to suppose, by La Place's expression, that the calculus of finite differences had then already assumed a systematic form, and that Fermat had actually observed the relation between the two calculi, and derived one from the other. The latter conclusion would scarcely be less correct than the former. No method can justly be regarded as bearing any analogy to the differential calculus, which does not lay down a system of rules (no matter on what considerations founded, by what names called, or in what extraneous matter enveloped,) by means of which the second term of the developement of any function of $x+e$, in powers of e, can be correctly calculated "quæ extendet se," to use Newton's expression, "*citra* ullum molestum calculum——in terminis surdis æque ac in integris procedens." It would be strange to suppose Fermat, or any other, in possession of such a method before any single surd quantity had ever been developed in a series. But in point of fact, his writings present no trace of the kind; and this, though fatal to his claim, is allowed by both the geometers cited. Hear La Grange's candid avowal: "Il fait disparaitre dans cette equation," that of the maximum, between x and e, "les radicaux et les fractions s'il y en à." La Place, too, declares, that "Il savoit etendre son calcul aux fonctions irrationelles en se debarrassant des irrationalités, par l'elévation des radicaux aux puissances." This is at once giving up the point in question. It is allowing, unequivocally, that Fermat, in these processes, only took a circuitous route to avoid a difficulty, which it is one of the most express objects of the differential calculus to face and surmount. The whole claim of the French geometer arises from a confusion (too often made) of the calculus and its applications, the means and the end, under the sweeping head of "nouveax calculs," on the one hand; and an assertion, somewhat too unqualified, advanced in the warmth and generality of a preface, on the other.

In what is here said, we would not be understood as desirous of stripping this really admirable mathematician of one particle of that fame which is, in justice, his due. He must be allowed to have seen very distinctly the use which might be made, in these inquiries, of the second term of the developement of à function, (supposed known,) and it is a purely accidental circumstance, that these views preceded the doctrine of series in a chronological order. Had Wallis and Kauffmann, who gave birth to this doctrine, lived 30 years earlier than they did, there is no saying to what extent Fermat might have been led; but the general state of knowledge, during the life of the latter, precluded any farther extension of his views. He was in possession of these methods, as well as a general theory of geometrical loci, equivalent to that of Descartes, in the year 1636, and even, as we may gather from one of his letters, seven years before; but so uncommunicative was his disposition, that his methods were always concealed, or very obscurely indicated; and in one remarkable instance have perished with him. We allude to his celebrated theorems in the transcendental arithmetic, several of which still remain unproved, and one of which, in particular, has for two successive years been made the prize question of the French Academy, without resolution. The worthy rival of Descartes, (who, however, could never be brought to render justice to his merit, though driven to subterfuges and chicanery in his opposition quite beneath his reputation,) Fermat, died in 1655, leaving behind him the merited fame of one of the profoundest geometers of his age.

The methods of these illustrious inventors, after some time, drew the attention of mathematicians, and commentators of a superior order endeavoured to exhibit them in a clear and useful manner. The Dutch geometers Hudde, Huygens, and Sluse, demonstrated and reduced the respective methods of Descartes and Fermat to their simplest terms, and to a set of rules universally applicable when the equation of the curve is freed from irrational and fractional terms. Something, however, was yet wanting. The acknowledged difficulty of extending these methods "citra ullum molestum calculum" to irrational and transcendental forms of the equation, draws a marked line of distinction between them and the differential calculus. The same may be said of the method of Barrow and his characteristic triangle, which, as far as relates to the drawing of tangents, is that of Fermat scarcely disguised, and limited by the same difficulties; and in all other respects, whatever facilities it may afford in the way of application, is as far from the differential, as the methods of Cavaleri and Wallis are from the integral calculus, bearing nearly the same relation to the former that these do to the latter.

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* In his *Theorie Analytique des Probabilités.*

A light, however, had by this time begun to dawn from another quarter. Wallis, just mentioned, a mathematician of the first order, and of a most original turn of thought, published, in the year 1655, his *Arithmetica infinitorum*, in which we first find that full reliance on what is called the *law of continuity* in analytical expressions, which has since led to so many brilliant generalizations. Stevin and Stiefel had long before introduced the use of negative and fractional exponents to express reciprocals and roots, but Wallis was the first to observe the full meaning and utility of this notation. After employing the method of indivisibles, much as Cavaleri had done before him, (only making use of algebraic language throughout,) to determine the areas of such curves as have in their ordinates any direct integer powers, or more generally any rational integral functions of the abscissæ, he then, seizing on this analogy, extended his conclusions to the inverse or fractional powers. Still the case of a rational fraction, with a denominator of the first degree, which would have given him the quadrature of the hyperbola, baffled all his efforts, and after many fruitless attempts he gave up the research.

The quadrature of the hyperbola was now no longer a matter of mere speculative curiosity. Practical utility was become deeply interested in the investigation by a discovery which the beginning of this century had produced, but which we deferred speaking of, that we might connect it with its proper link in the great chain of invention. Napier, heritor of the Scotch barony of Merchieston, struck with the difficulties which encumbered arithmetical computations of any length, and which various circumstances had about that time concurred to place in a very prominent light, after bestowing much fruitless labour on the invention of mechanical contrivances for multiplication and division, rejected this plan, and struck on the happy idea of logarithms. It is true that Stiefel, in 1544, had spoken of a series of quantities in arithmetic progression corresponding to another in geometric, had noticed their chief properties, and exemplified some of their uses; but he did not reduce his ideas to practice by constructing a table of their values, nor does it appear that Napier knew of his work. Having conceived this idea, the next thing was to construct a table of their values, which Napier performed by peculiar considerations not necessary to notice; but the table being still inconvenient, from the logarithms being all of the natural or hyperbolic kind, Briggs, professor of mathematics at Gresham, who, as soon as he heard of Napier's discovery, entered with a kind of enthusiasm into his views, soon devised, in conjunction with Napier, a means of remedying this evil, by diminishing all the logarithms proportionally, (which does not alter their useful properties,) so as to make the logarithms of 10 unity. The death of Napier, which happened while this great improvement was yet under discussion, did not abate, but rather increased the ardour of Briggs; who, with indefatigable industry, at length completed a very extensive table in this new form.

The invention of logarithms was a most invaluable present to the calculator, but its influence extended still wider. Gregory St. Vincent, in 1647, had demonstrated the grand property of the hyperbola which connects its area with the logarithmic function; and Kauffmann (Mercator, as his name is latinised,) pursuing this subject, at length, in his *Logarithmotechnia* (1667), distinctly reduced the construction of logarithmic tables to the quadrature of hyperbolic spaces. The unsuccessful attempts of Wallis now came under his contemplation; and what that geometer could not accomplish, Kauffmann effected by the simple, but happy idea, of continuing the division of the numerator by the denominator to infinity, as in the decimal arithmetic, and applying the method of Wallis to the series of positive powers which results. The first general quadrature of the hyperbola was thus obtained, at the same time that the regular developement of a function in series was now distinctly exhibited. It is astonishing, after this, that he did not attempt the extraction of roots by the same process, especially as Wallis had equally failed in his attempts at the indefinite quadrature of the circle whose ordinate is the square root of a binomial, though he succeeded in obtaining the whole area by a method of interpolation, the most singular which perhaps ever occurred to the mind of man.

Such were the grounds on which Newton was to raise the mighty fabric of his mathematical discoveries. Previous to the publication of Kauffmann's series, the perusal of Wallis's work, as himself relates, had led him to consider how the general or *indefinite* values of the areas of a series of curves might be interpolated, the interpolation of whose total or definite values had afforded that writer his quadrature of the whole circle. This was a work of incomparably greater facility than that undertaken by Wallis, and his undertaking was accordingly successful. It immediately struck him, that the same method of interpolation might be applied to the ordinates as to the areas; and, by pursuing this idea, he arrived at his *binomial theorem*, which proved the key to the whole doctrine of series. It was natural to attempt the verification of the results so obtained by other methods; and that employed by Kauffmann as naturally occurred, and was adopted in the exposition of these discoveries, in a small work, *Analysis per æquationes numero terminorum infinitas*, communicated to his friends, Barrow, Oldenburg, and Collins, in 1669, which gave occasion to Barrow to characterise his method as an extension of that of Kauffmann.

The use of the infinitely small increments of quantities, or the second terms of their developements, was about this time, to a certain extent, pretty generally understood. The methods of Fermat on the continent, and Barrow in England, had shewn its application to the investigation of maxima and the theory of tangents; so that it might have been predicted, *a priori*, that the first geometer who took any extensive views of the developement of functions into series, would apply them to overcome the acknowledged difficulties which embarrassed these methods, and which consisted in the want of some general method of estimating the increments of radical and fractional expressions without reduction. To a genius like Newton's, this presented itself with his first ideas on series; and so early as 1669, we find him in possession of those "general analytical methods" which wanted only refinement and reduction to a regular system of calculation to be the differential calculus.

The discoveries of Newton on series, at least their results, were widely spread abroad by the correspondence of Barrow, Collins, and Oldenburg; but the system of rules in which the analytical part of the method of fluxions consists was studiously concealed, nor had any thing whatever on the subject appeared in print. About the beginning of the year 1670. Leibnitz, destined to play so conspicuous a part in the future history of analysis, appeared for the first time in London. England was then the focus of mathematical ardour; and it was scarcely possible to converse with the scientific society into which Leibnitz was introduced, without catching some portion of the flame, and perceiving the direction which improvements were taking. The new discoveries in series were the universal subject of conversation; and though Leibnitz had hitherto occupied himself but little with the higher geometry, it is not wonderful that, on his return to Paris, we should find him busied with the study of Gregory St. Vincent and Kauffmann,* the only public sources from which information on the subject could be obtained. His studies were rewarded, before the end of 1674, with a series for the quadrature of the circle, which he immediately hastened to communicate to Oldenburg, the secretary of the Royal Society of London, assuring him, at the same time, that he was in possession of very general analytical methods. In the method by which he obtained this series, (by rationalizing the expression of the increment of the area by a very ingenious process, and treating the *rational fraction* so arising as Kauffmann had done in the case of the hyperbola,) we have not only every mark of independent invention, grounding itself on Kauffmann's process, but also a plain proof that he was then ignorant of the binomial theorem, and Newton's process for extracting roots. Nor is there any thing surprising in this; James Gregory had, from the same data, a little while before, not only arrived at the same quadrature of the circle with Leibnitz, but even put himself fully in possession of the method of series—a fact allowed on all hands; and the enemies of Leibnitz, however inclined to stigmatize his moral character, have never ventured to deny his genius. A correspondence thus commenced between Leibnitz, Oldenburg, and Collins, which continued till the year 1676, when Newton himself addressed two letters to Oldenburg, for the purpose of communication to Leibnitz. In these, the method of series and the binomial theorem are very fully explained; and, in the latter of them, Newton declared that he was in possession of a general method of drawing tangents, by which we *now* know the method of fluxions was meant, but which he carefully concealed in an anagram, at the same time so fully describing the advantages of his process over all then in use, as to render it evident that this method, whatever it might be, was the great desideratum which had so long escaped geometers. Supposing, then, that Leibnitz had already no conception of the kind, it is not to be wondered at that his curiosity, thus stimulated, should prompt him to the highest exertion of his inventive powers. Newton had said enough, and indeed it might have been concluded, from a multitude of indications, that the new method was immediately connected with the theory of series. Of this theory he was now in full possession. What might have been expected, in such circumstances, happened. Leibnitz, in the summer of 1677, addressed a letter to Newton, containing the principles of his differential calculus, which the latter acknowledges to have differed from his own merely "verborum ac notarum formulis, ac in ideà generationis quantitatum."

The character of the German philosopher has, in consequence of this transaction, and of some degree of unnecessary vanity on his own part, been attacked with all the virulence of national partiality. On the strength of these letters of Newton, and of another to Collins, in which he explains a method of tangents, equivalent, as he supposes, to that of Sluse, and speaks of it as a corollary or particular case of a more general method which he possesses, and of which (as in his letter to Leibnitz) he avoids farther explanation, as well as of an interview between the latter and Collins in 1676, in which (without any proof) it is *presumed** that he saw the MS. of the *Analysis per æquationes*, where the method of fluxions is obscurely exposed, a charge of plagiarism, the most direct and unmitigated, has been grounded. On weighing the whole evidence, however, the most unfavorable conclusion that justice will allow us to draw, seems to be, that the views of Leibnitz, opening on him by degrees, even before the full importance of them was sensible to himself, some occasional gleams of that general light, which the discoveries of Newton on series were beginning to spread, might mingle unperceived with the dawnings of invention in his own mind. The acknowledged genius of this illustrious geometer, no where more strongly manifested than in his immediate perception of the extent to which the differential calculus might be carried, and the important improvements he afterwards made in it, as it renders the supposition of plagiarism unnecessary, ought to place him above the suspicion. We say the most unfavorable conclusion, because there was obviously another, and more algebraical way, (if we may so express ourselves,) of arriving at the differential calculus, without any assistance whatever from series, which there is every reason to suppose was that actually pursued by Leibnitz; we mean, the consideration of the cotemporaneous infinitely small increments of variables connected together by algebraic equations, which enables us to rise by degrees from the differential of a product to that of a square, thence to a cube, and so on by induction, to any integer power; thence again to descend by a mere algebraic artifice to fractional and negative powers, and so on to the powers and roots of compound quantities: and thus, without any knowledge of series, or the binomial theorem, to discover a system of rules for the direct computation of the infinitely small increment of any algebraic function. Fermat's method of tangents and maxima, with the illustrations it had received when Leibnitz first turned his thoughts to the subject, would strongly suggest some such idea.

It ought not to be forgotten, in our estimate of the circumstantial evidence of the case, that the conduct of Leibnitz, from the first agitation of the question in 1699, till his death, which happened in 1716, was that of conscious innocence. Attacked with intemperate, and even vulgar acrimony, by Nicholas Fatio, and afterwards by Keill, he defended himself with the candour and moderation of a philosopher, and in the firm but decent language of a gentleman. He hesitated not a moment to appeal to Newton and the Royal Society, of which he was then president, making them, with a confidence honourable alike to both parties, judges in their own cause; and if that illustrious body, in their examination of the case, have fully established the *priority* of Newton's claim, it will be remembered, that they must not be regarded, on that account, as sanctioning the injurious comments with which Keill accompanied the collection of letters afterwards printed under the title, *Commercium Epistolicum de analysi promotâ.*[*]

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* It may seem pedantic to deviate from common usage in giving this geometer always his right name; but we do it, to avoid the possibility of confounding him with Gerard Mercator, the inventor of the charts—a confusion which has led even the accurate Hutton into the very great absurdity of placing his death in the year 1594, 46 years before his birth. The true time of his death is unknown.

† From an expression of Leibnitz, which will even bear the contrary sense.

On the whole, this famous quarrel is of much less real importance in the history of the mathematics than it is usually considered. Unlike the quarrel of the Bernoullis, (from which it sprung) which gave rise to such a train of splendid discoveries, unlike that of Cardan and Tartalea, which influenced so much the early progress of algebra, this odious dispute, started by inferior men, long after the parties in question had acquiesced in each other's independent claims, has never given rise to a single discovery of note, while its effects have been fatally sensible in blasting the progress of analysis in England, and prejudicing the countrymen of Newton against those improvements, to which alone the continental geometers owe their glorious verification of all his sublimest views. We quit the subject without regret, to resume our history.

The first public promulgation of the differential calculus was made by Leibnitz in 1684, in the Leipsic acts. In the short paper which contains it, the rules are given without proof, &c. which is particularly to be remarked; the algorithms of the calculus is, from the first, regarded as an essential integrant part of the system. It appears to have been the object of Leibnitz to place in the hands of geometers an instrument, ready prepared for use on all occasions, without the necessity of recurring to first principles. His paper, in June 1686, (*Act. Lips.*) shews how rapidly his views of the power of his notation, as a means of reducing questions to symbolic language, without the introduction of series, extended, and it is in this regular algorithm and reduction to a stated calculus that the merit of Leibnitz's views entirely consists. The pointed letters of Newton were not given to the public till long after. If we are not mistaken, Wallis exhibited the first specimen in 1699. The *Quadratura curvarum*, in which Newton explained his own notation, was not published till 1704.

The mixed mathematics, which had hitherto been cultivated to little purpose, had however for some time begun to attract attention. The first correct ideas respecting mechanics were, as we have seen, suggested by Archimedes. In the knowledge the ancients had of the power of the pulley, they possessed a principle, which, as Lagrange has most beautifully shewn, might have sufficed to put the whole theory of statics in their power, but, for want of general methods and extent of conception, it remained barren in their hands. Galileo, among the moderns, was the first who rejected the absurd ideas of the Aristotelian school concerning motion, and established, in 1592, the fundamental principles of dynamics. He correctly estimated, shortly before his death, the effect of gravity, regarded as a uniform accelerating force, in the descent of heavy bodies and the paths of projectiles. We may judge of the state of dynamical knowledge before Galileo, by the opinion universally prevalent, that heavy bodies, being more acted on by gravity, must fall with greater velocity than light ones. The theory of centres of oscillation was soon after discussed, and the three great laws of motion were at length distinctly propounded by Descartes. The cause of gravity too, and the explanation of the motion of the heavenly bodies, were already made subjects of consideration; and while the fanciful hypothesis of the Cartesian vortices reigned triumphant with the generality of the learned, two of our countrymen, Halley and Hooke, must be allowed the merit, about the period of Newton's grand discovery, of indulging notions more conformable to nature. Halley even went so far as to conclude from Kepler's law of the periodic times of the planets, that they were retained in their orbits by centripetal forces inversely as the squares of their distances from the sun, but not being able to put his reasoning into a geometrical form, applied to Newton at Cambridge. He there found that great man beforehand with him, having already communicated his principal propositions on the planetary motions to the Royal Society in 1683. At the earnest persuasion of Halley, Newton resumed his investigations, and at length, in 1687, appeared the Principia, an immortal work, which, were all his other claims to the title deficient, must for ever stamp him the profoundest of geometers as well as the first of natural philosophers. It was now that the real value of mathematical investigation in natural philosophy became apparent. Relying on this unerring guide, and aided by instruments of his own creation, Newton ascended by regular steps from the two great facts, the ellipticity of the planetary orbits, and the equable description of their areas round the sun in their focus, which Kepler had established as a result of observation, to the general law of gravity, decreasing as the square of the distance. Descending again from this principle, and tracing it to its remoter consequences, the leading inequalities of the lunar motions, the phenomena of the tides, the precession of the equinoxes, and the seemingly irregular motions of comets, were recognised as dependent on this great law of nature. But the instruments of Newton, powerful as they were, and employed with almost super-human dexterity and penetration, proved insufficient to carry the inquiry into all its minuter ramifications. With every inequality accounted for, a long progression of subordinate effects became visible, to which the application of the geometrical methods then seemed hopeless. The mutual actions of the planets might give rise to a series of perturbations, small in themselves, but accumulating with the lapse of ages, till the disorder so induced in the system might surpass the reach of any self-compensating power, and be rectifiable only by the hand which made it. Such was the view, which, as we learn from a passage in his Optics, actually suggested itself to Newton. But to enter upon this field was beyond the state of mathematical knowledge, even with the improvements of the next half century, yet it is not the least glory of Newton to have transmitted to posterity, in his method of successive approximations, an instrument, whose powers, developed and refined, have ultimately afforded the solution of every difficulty, and established at once the universality of the law of gravity, and the stability of the system it controls.

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[*] Leibnitz has certainly been treated unjustly by some of the partisans of Newton; but, on the other hand, his friends have not been wanting in point of acrimony. I am sorry to find, in Montucla's account of the dispute, an anecdote, which, as a man of judgment, he ought to have rejected with contempt. He asserts, on authority which he does not choose to name, that "les notes qui accompagnent le Com. Epist^{m}. sont *de Newton meme.*" This, in its plain sense, is impossible. It would go to prove Newton profoundly ignorant of his own method. La Croix, willing to preserve the malignity of the imputation, but sensible, as it should seem, that it would look too strong in these words, has substituted *des* notes for *les* notes, in his citation of this little piece of scandal from Montucla. "Newton ajouta de sa main des notes." *Preface to the Traite du Calc.* &c. 4to. 2d edit.

The publication of the Principia, a work so infinitely beyond the general state of science in which it appeared, was not immediately followed by any great extension of its author's views. In fact, he had carried the application of all the methods then in use, as well as those peculiar to himself, nearly as far as their nature was susceptible of, (as the event has amply proved.) There were few who could make themselves masters of his work, and none capable of adding any thing of consequence to it. Meanwhile, the continental analysts of the Leibnitian school were silently busied in creating new methods, and improving in particular the integral calculus, from which alone any farther assistance was to be expected. The Leipsic acts were now continually teeming with excellent papers by Leibnitz and the Bernoullis, his disciples and friends, on this subject, and before the end of this century the analytical methods had attained a considerable degree of elegance, as well as a great accession of extent and power. In order to trace with clearness the history of their successive improvements, it will be unavoidable to depart occasionally from the chronological arrangement we have hitherto followed, and by subdividing our subject to a certain extent, avoid that confusion which the rapid and close succession of discoveries during the last century, especially towards its latter end, would otherwise entail on the account. By this means we are not without hopes of being enabled to exhibit, though not a complete picture, yet at least a general outline of the present state of analytical science, though the difficulty of condensing so vast a subject within any reasonable limits, without allowing the account to degenerate into a mere catalogue of books and names, must still remain very great; especially when we consider that, such is the nature of pure mathematical science, and such the perfect connexion between its most remote parts, no great improvement can be made in one of its branches without putting in motion a long chain of consequences, and restoring fertility to subjects and to methods which had before been abandoned as exhausted. By thus returning to the attack with more effective arms, and as it were from a higher ground, difficulties have repeatedly been surmounted in one state of analysis, which in its preceding stages seemed almost hopeless. This, it must be allowed, is a very cheering prospect to the analyst, as it teaches him never to despair of one day seeing his most embarrassing obstacles vanish before him; but it renders the task of the historian who recounts his labours more complicated, in proportion to the difficulty of keeping separate subjects which have become so interwoven in their progress.

Among the first to acknowledge the utility of the differential calculus was Craig, an Englishman, who imported it into this country, with its notation, before its publication by Newton; but so new were ideas of this kind to the continental geometers, that the force of the algorithm not being directly perceived, and no cultivators at first appearing, Leibnitz, in 1687, to excite attention, proposed the curve of equable descent. The difficulties which this problem offered to the methods usually studied, opened first the eyes of James, the elder of the Bernoullis, professor of mathematics at Basle, who immediately set himself to study and improve the calculus. In this he was shortly after followed by his brother John, and among these three an interchange of difficult problems took place, in which they were soon joined by Huygens and Tschirnäus. As the differential calculus at first was wholly confined to its applications in the theory of curves, a multitude of new curves were conceived, and new properties relative to the areas, arcs, &c. of old ones demonstrated. The geometers of those days are not masters of themselves when the wonders of the cycloid are the subject of their eulogies. The catenaria too, the elastic curve, the theory of radii of curvature, evolutes and caustics, rose in rapid succession under their hands, but the most celebrated of the problems which at the end of this century engaged their attention, whether we regard the difficulty of the subject, the disputes it occasioned, or the consequences to which it afterwards led, was that of isoperimetrical curves, proposed in 1697. The minute history of the origin of this celebrated problem, the reader will find under our article *Isoperimetrical Problems*. It will only be necessary to mention here, that it was proposed by James Bernoulli, in consequence of a public defiance by his brother, who, foiled in all his attempts, and convicted of numberless paralogisms in his obstinate defence of a solution radically defective, at length entirely lost his temper, and suffered the merited punishment of that overweening vanity which prompted him to the contest—a vanity conspicuous in all his writings, and for which even his extraordinary mathematical attainments can afford no excuse. The contest ended only with the death of James in 1705, after which his brother, to a certain extent, redeemed his *mathematical* credit by a very excellent memoir published by the French Academy in 1718, in which he was however compelled to adopt, with a very ill grace, the principle of the beautiful analysis given by James in 1701, which indeed became the ground of all subsequent researches on the subject till the invention of the calculus of variations. It was not, however, till many years after that the subject was treated with any great generality. The opening genius of Euler found at length an ample field for its exertion in the difficulties which this class of problems presented, and after gradually rising in extent and refinement, in several memoirs published among the earlier Petersburgh acts, his general analysis appeared in 1744, under the title *Methodus inveniendi lineas curvas maximi minimive proprietate gaudentes*. an admirable work, in which profoundness of investigation is perhaps more strikingly blended with elementary clearness of statement, than in any of the almost innumerable instances of the kind with which the writings of this wonderful man present us. The subject, however, was not yet exhausted. Its consummation was reserved for a later period, and for a calculus of a higher order; but at present it will be necessary to resume the history of the improvements in the integral calculus.

The integration of explicit functions, connected as it is with the quadrature, rectification, &c. of curves, was naturally the first object to which attention would be turned. Newton and Craig were the first to pursue the subject to any extent. The former, in his treatise *de Quadraturâ curvarum*, integrated such cases of irrational as well as rational forms of the most ordinary occurrence, as are reducible either to algebraic terms, or the areas of the conic sections. This work, however, though mostly written 20 years before, by the effect of that repugnance to publication which forms so remarkable a feature in Newton's literary character, did not appear till the year 1704. That useful process of reduction, known in our English elementary treatises by the name of the *comparison*, or *continuation of fluents*, is here delivered, and Craig first used the *integration by parts* for the same purpose. About the same time, (1702) both Leibnitz and John Bernoulli, independent of each other, had taken a very extensive view of rational fractions, and explained the general and elegant theory of their reduction, however complicated, to others in which the denominators are binomials, or their powers founded on Harriott's theory of equations, and the method of indeterminate co efficients invented by Descartes. By the aid of these processes, the integration of all rational differential expressions is universally reduced to algebraic and logarithmic terms. But here a difficulty arose which appeared to Leibnitz insuperable, at least in the then state of analysis. The denominator of the fraction to be reduced might always, it is true, be shewn capable of reduction to simple factors, but some of these might involve imaginary expressions. If so, the integral would be reduced to the quadrature of an imaginary hyperbola. Leibnitz however observed, that as every imaginary root must have its corresponding one, the reduction of the two simple fractions thence arising into one, would produce a real fraction with a quadratic denominator, and would introduce by that means arcs of circles into the integral. This would happen when the roots could be actually ascertained and insulated, but Leibnitz did not observe that the question of the *possibility* of so reducing his fractions, differed widely from that of its *practicability*, and accordingly concluded, that in some cases, (particularizing $\frac{d\,x}{x^4 + a^4}$, and other fractions of the same form) the denominator might not be reducible to real quadratic factors, and the integration might not depend on the quadrature of the circle or hyperbola, but on some new transcendent unconnected with either. The first general demonstration of that grand proposition in the theory of equations, on which the perfect elucidation of this difficulty depends, was given some time after by Euler, and indeed Bernoulli said enough to have convinced Leibnitz of his error, had he not been misled by his strange metaphysical notions of the variety in which nature delights, and by a certain vagueness of conception relative to imaginary quantities.* The doubts started by Leibnitz, however, in all probability engaged our countryman Cotes, (one of the most promising mathematicians among the contemporaries of Newton, whose friendship he was so fortunate as to merit and obtain) in the investigation of that beautiful theorem which bears his name, and of which we shall presently speak more fully. Meanwhile, John Bernoulli was making a step, which for the first time transgressed that mysterious terror in which imaginary quantities had hitherto held mathematicians. By applying his method of resolving fractions into simple ones to the differential expression of the arc in terms of its tangent, (*i. e.* by reversing the process of Leibnitz in similar circumstances,) he arrived at the expression of the arc of a circle, in terms of an imaginary logarithm. The analytical connexion between the circular and hyperbolic sectors was now perceived, and the application of the exponential calculus alone was wanting to perfect the theory of angular sections. But in this respect Bernoulli seemed pursued by some fatality, and one of the most beautiful and useful discoveries which he held as it were within his grasp, escaped his notice. We mean the exponential expressions of the tangent, sine, and cosine of a circular arc.

The notation of exponents was invented by Descartes, but Wallis, as we have seen, was the first who regarded such an expression as x^n as a function of n. To John Bernoulli, in 1697, we owe the first systematic examination of the exponential function. It is true he contented himself with some of its more obvious properties, and the investigation of its differential. Its developement (regarded as the inverse logarithmic function) had been obtained by Newton by the reversion of series, as well as those of the sine and cosine of an arc, in his correspondence with Oldenburg, so that there was no reason why the theory of angular sections should not then have been rendered complete; but when John Bernoulli had taken the step we have just mentioned, it is indeed surprising that the connection of the latter functions with the fundamental transcendent e^x should have been overlooked.

The principal properties of the chords of multiple arcs had been given by Vieta in 1600, and it is not impossible that, from these expressions, from which it may be had by a very simple transformation, Cotes might be led to the discovery of his celebrated theorem for the resolution of the function $x^n \pm a^n$ into its quadratic factors. Had he lived to publish his own investigation, Demoivre, who afterwards pursued the same subject to its completion, would probably have been deprived of this part of his mathematical fame, as it is not easy to imagine how Cotes could have obtained the particular case which constitutes his theorem, without passing through the general formula investigated by that geometer in 1722 for the resolution of $x^{2n} - 2x^n .\ \cos.\ \theta + 1$. The embroiled state of Cotes's MSS. at the time of his premature death in 1716, (*foliis sybillinis obscurior*,) probably prevented his friend Dr. Smith, into whose hands they fell, from perceiving the full extent of the author's meaning. In 1730, Demoivre again signalized himself in the same career, by that theorem which is generally known by his name, and which can scarcely be said to yield in beauty, or in the multitude of its applications, to the binomial theorem itself. It is immediately deducible from Bernoulli's expression; and one of its most obvious applications is, the expression of the sine or cosine of a multiple arc in powers of those of the simple arc. Bernoulli, in 1701, had arrived at this expression; so that he twice touched on this discovery without observing it. Euler at length put the finishing stroke to the theory of angular sections by the discovery of the exponential forms, which seem to have been purposely overlooked by every other writer, so obvious were they. He arrived at them, too, (*Miscell Berolin.* vii.) just as Newton might have done, from the three series given by that great geometer in 1676. Nothing was now wanting to the perfection of analytical trigonometry but a convenient algorithm, which was also supplied by Euler, (though the chief theorems, on which its most usual applications to geometry depend, were pointed out before him by Christian Mayer,) who by this means put into the hands of the mathematician an instrument of investigation, without which it would be almost in vain to enter upon any of the more difficult inquiries of the mixed mathematics, and to which the theory of the celestial motions is peculiarly indebted.

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* He calls them in this paper " monsters of the ideal world, amphibious between existence and non-existence," &c

We return from a digression, which the importance of this part of our subject has obliged us to render somewhat minute, to the theory of explicit integrations, and the gradual introduction of the new species of transcendents they lead to; and as this branch of analysis has not received any very great assistance from others, depending almost exclusively on its own resources, we shall take the opportunity to continue its history up to its present state.

As the evaluation of transcendents, by the construction of tables, and the reduction of others to more or less complicated combinations of the tabulated ones, is the ultimate object of all inquiry into their properties, the choice of the fundamental transcendents is a matter of great importance. The areas of the conic sections were at first selected from geometrical considerations; but it was soon perceived, that arcs of circles and logarithms would be far preferable in analytical inquiries. It is to Cotes to whom we owe this very great improvement, laid down in the *Harmonia Mensurarum*, published in 1722 by Dr. Smith, though Leibnitz seems also to have had some idea of the kind, which, however, he never formally propounded. By this means, the computation of all such integrals as depend on these transcendents is reduced to its minimum of complexity. But it was speedily perceived that these alone were insufficient for the expresssion of all integrals. After the general integration of rational differentials, the next step was that of irrational ones. It is to Leibnitz we owe that very ingenious idea of employing the Diophantine analysis, which had before been looked upon as a mere matter of useless curiosity, to *rationalize* such expressions, and thus reduce them to the preceding forms. Unhappily, however, this process has been found restricted in its applications, failing in most instances, unless where the function to be rationalized involves only a radical of the form $\sqrt{a + bx + cx^2}$; in which very extensive and useful case it is however completely successful. Yet the reasons of its failure, as well as of its partial success, were never examined until very recently, when Mr. Bromhead, taking a view of, I had almost said daring generality, showed (*Phil. Transactions*, 1816,) that all the known integrable forms of irrationality are particular cases of others of the greatest extent, not dependent on particular functions, but on the general properties of all rational functions whatever, and has thus been led to a variety of new integrable forms. This may serve to show what advantages may be derived from continually inquiring the reasons why analytical processes succeed in certain circumstances, and from what particular adjustment of our formula it arises, that such and such substitutions produce such and such effects.

The next general form of irrationality which came to be examined, was that of the integral $\int \frac{\mathrm{P}dx}{\mathrm{R}}$, P being a rational function, and R the square root of a polynomial of the fourth degree. This is the form of those denominated, by Legendre, elliptic transcendents; a most extensive class, and whose theory has at length, by the successive researches of Fagnani, Euler, Landen, Lagrange, Ivory, Wallace, and Legendre, been brought to extraordinary perfection. It was at first imagined that the fundamental transcendents of this kind were the arcs of the conic sections, but a careful examination of their general expression has shown this choice to be repugnant to their nature. Legendre has divided the transcendents comprised in the general form into three distinct species. The first is susceptible of multiplication and division, in the same way as the arcs of circles and logarithms, by mere algebraic operations. The arc of an hyperbola is a transcendent of this species, which is the simplest of the three. Those of the second species are susceptible of a similar multiplication and division, not simply, but when increased or diminished by certain algebraic functions. Of this nature are the arcs of ellipses. This algebraic function passes, in the third species, into a transcendent of the logarithmic or circular kind. The surface of an oblique cone requires this species for its general expression, but transcendents of this form are not reducible to the arcs of any conic section. The theorem of Fagnani, for the comparison of elliptic arcs, is well known, but that of elliptic transcendents, in general, has been shown by Legendre to depend on a very remarkable analytical artifice of Euler's, by which he was enabled to exhibit the integral of a differential equation, by an algebraic relation between the variables, which, integrated by the ordinary process, assigns a relation between the transcendents composed of them. (*Nov. Comm. Petrop.* vi. vii.) Lagrange attempted in vain to arrive at a more general result than that of Euler, which seems limited in its application at the very point to which that geometer carried it. Our countryman Landen, one of the most profound and original analysts that England has to boast, made the next great step in their theory, by reducing the rectification of the hyperbola, in general, to two elliptic arcs, a discovery of the greatest importance, as it limits the number of distinct transcendents in the general form to two. Various methods have been devised of approximating to their values, by means of series conveying with more or less rapidity, of which those delivered by Mr. Ivory and Mr. Wallace in the *Edin. Trans.* iv. and v. are not the least elegant. The most complete investigation of their properties, their evaluation, and the integrals which may be reduced to them, has, however, been given by Legendre, in a memoir communicated to the Academy in 1786, and in a separate memoir, and finally digested in one work, his *Exercises de Calcul Integral* in 1811. Mr. Woodhouse, in an able paper in the *Phil. Trans.* 1804, has endeavoured, not without success, to show that the various processes for attaining conveying series for their evaluation, are for the most part reducible to one very simple and natural substitution, first given by Lagrange, an attempt to which, as it tends greatly to abridge and simplify the labour of the mathematical student, the highest praise is due: this memoir of Mr. Woodhouse is remarkable in another point of view, for the boldness with which he rejects the use of geometrical language and considerations in analytical inquiries. He is, if we mistake not, the first of the English mathematicians who has ventured to speak so decidedly on that subject.

The remaining species of transcendents, on which (in their indefinite form) much inquiry has been bestowed, are not numerous. Kramp, in his *Analyse des Refractions*, has examined and given tables of that comprised in the form $\int e^{-x^n} dx$, while Spence, a Scotch mathematician, of a very superior order, in his *Essay on Logarithmic Transcendents*, (1809,) has taken up the theory of those comprised in the form

$$\int\frac{dx}{x}\int\frac{dx}{x}\ \ldots\ \int\frac{dx}{x}\ \text{log.}\ (1+x);$$

and others of a similar nature, has calculated tables of their numerical values, exhibited general, yet simple relations between their various orders, and reduced a vast variety of integral forms to their combination. In this research he stands almost alone, having been anticipated but in a few very particular cases by Euler and Landen. A premature death intercepted the chain of his researches; but in his MSS. which have been submitted to the inspection of the writer of this article, and which are, or shortly will be, before the public, are the outlines of yet more general inquiries, in which classes of transcendents of a most interesting nature are pointed out, and their properties examined.

Yet at last it will often happen, that an integral will present itself of too intractable a nature to yield to any transformation, or come under any tabulated form. In such cases the resolution into conveying series is usually impracticable, and the "method of quadratures" (as it is now called) is our last resource. Newton first noticed the possibility of estimating the area of a curve from a limited number of its known ordinates; but Legendre has well remarked, that the principle of his solution is essentially defective, inasmuch as the parabolic curve he proposes to draw through the extremities of the known ordinates, may deviate considerably in the intermediate places (and of course in area) from the actual transcendental curve under consideration. It is impossible to give any idea here of the profound researches of Legendre on this subject: suffice it to say, they put it in our power to assign the value of any explicit integral to any assigned number of decimal places.

The integration of differential equations, the next great branch of the integral calculus, on which most of of the more profound theories in the mixed mathematics rest, has scarcely received that attention in Britain which its extreme importance would lead us to expect. The first example of the treatment of such an equation by the separation of the variables, was given in 1694, by John Bernoulli, in the solution of a geometrical problem; and in the following year, James, as if resolved on surpassing his brother in every point, proposed the general equation of the first order and degree, or at least one equivalent to it. A few months afterwards the solution was indicated by Leibnitz, but in so imperfect a manner as to oblige us to rely on his positive assurance that he had integrated it long before, and communicated it to his friends, before we can allow him a share in the discovery. John Bernoulli, in 1697, gave the first regular analytical solution of the equation. It must be confessed, however, that in this, as in almost every branch of mathematical knowledge, Newton had long before led the way. The construction in the 29th prop. of the 2d book of the Principia, could not have been accomplished without the actual integration of a linear equation of the form $\frac{dy}{dx} + a\,y = x$, unless by a sagacity little short of miraculous. This equation affords no particular facilities, the constant co-efficient making little difference in point of difficulty between it and the general case: and if in this instance, as well as in that of the isoperimetrical problem resolved by him in the same immortal work, he did not, by dwelling on, and generalizing his processes, sweep before him the discoveries of half posterity, it can only be attributed to his unfortunate partiality to the geometrical methods of the ancients, which rendered him averse to pursuing his analitical ideas, unless with some great application immediately in view. Or perhaps we should rather say, that his genius, disdaining the artificial aids of regular algorithm and symbolic contraction, seized on all occasions on the immediate principles of the question, and applied them as it were in their rude and natural state to its solution, unconscious of this high privilege which distinguished him from all other men, and perceiving no necessity for embodying his subordinate views in calculi and systems.

The integration of differential equations was now taken up as a separate branch of inquiry, but the separation of the variables was the only artifice resorted to. The possibility of executing this in all homogeneous equations was the next step of any generality, and was made by John Bernoulli. Some other forms too, among which that remarkable one discovered by Riccati, and known by his name, (of which Euler has given a very complete theory, by the help of continued fractions in the *Com. Petropol.* for 1737) were noticed about this period, but no general view of differential equations had hitherto been taken. A new generation of illustrious men were now entering on their career, a generation characterized by fertility in analytical artifice, by the generality of their conceptions, and by indefatigable research. The younger Bernoullis, (Nicholas and Daniel) Euler, Clairaut, Fontaine, and D'Alembert, now began to launch out into that open ocean of analytical inquiry, along whose borders their predecessors had only ventured to coast. Every branch of mathematical science was now to be resumed upon a wider scale. The resources of symbolic language were become more developed, and furnished by its means with unlimited facilities for the representation of magnitude, geometers seemed at length determined to set no bounds to their excursions, but those within which the limited faculties of the human mind must eternally confine them.

The first step which led to a more profound examination of the nature of differential equations, was the method proposed by John Bernoulli, in the first publication of the academy of St. Petersburgh, then lately instituted, (1728) for integrating certain differential equations without the previous separation of their variables. This led to a consideration of the conditions which must hold good, in order that such an integration may be possible without any previous preparation, or in other words, that any proposed differential expression may be the result of the immediate differentiation of some function of the variables. The first essays of the theory of *equations of condition* had already been made by Nicholas Bernoulli, in a memoir on the problem of orthogonal trajectories in 1720, and the subject was some years afterwards pursued independently, by Euler, Fontaine, and Clairaut, nearly about the same time (1740). The equations of condition, usually known by the name of "criteria of integrability," were observed by each of these geometers, but Euler, extending his views further, shewed how they might be employed to determine a factor, by which a differential equation being multiplied should become immediately integrable. This method of discovering the integrating factor, it is well known, leads to equations of partial differences, and of course those which Euler obtained were of this kind, but their peculiar nature was not perceived at that time, owing to the object in view, which is accomplished when any particular value can be found to satisfy them; so that the extreme generality of the integrals they admit was not observed, and the distinct perception of the nature of partial differential equations was reserved for another occasion. The theory of these conditions of integrability has been included in elegant and general formulæ by Euler and the Marquis Condorcet; but the principles on which they were considered involved some degree of obscurity. The most complete elucidation of their nature has however been afforded by the light in which Lagrange has exhibited the differential calculus, nor can any thing be more elegant, simple, and satisfactory than the analysis he has given of them in the 21st Lesson of that admirable work, *The Calcul des Fonctions*. Nor is this inquiry a matter of mere curiosity, independent of their use in the theory of differential equations. They are intimately connected with the formulæ of the calculus of variations, and in the mixed mathematics their use is of fundamental importance, as the possibility of satisfying the conditions of equilibrium of a fluid depends entirely on their verification.

The greatest light, however, was thrown upon the theory of differential equations by Fontaine, who, in a series of investigations, presented to the French academy in 1738, (but whose publication was, for some unknown reason, delayed till 1764,) first considered the manner in which any differential equation can arise from the equation, known or unknown, which expresses its integral. By this view of the subject he was enabled to demonstrate those general properties of all such equations which depend on the theory of the arbitrary constants, as that every differential equation, of whatever order, has as many distinct integrals of the next inferior order as is expressed by the exponent of its order, and no more; from which it results as a necessary consequence, that the complete finite integral of any equation, in whatever variety of disguises it may appear, is necessarily unique, comprising as many arbitrary constants as the exponent of its order denotes, whose elimination will of course reproduce the proposed differential equation. To these researches of Fontaine we owe that elegant and expressive system of notation to designate the differential co-efficients of a function relative to its several variables, which is now universally adopted, and which a slight modification would render the most perfect the nature of the subject seems to admit.

But these conclusions only tended to render more paradoxical a remark made by Euler, that many differential equations admit solutions which can in no way be included in their complete integral. Such *singular solutions* had occurred to Leibnitz and the Bernoullis, at the first origin of the integral calculus in the resolution of geometrical problems, but the peculiar modes in which they conducted their investigations prevented their observing any thing extraordinary in their results. Our countryman Brook Taylor, in his *Methodus Incrementorum*, (1715,) was the first who arrived at such a solution from the immediate consideration of the differential equation, and as he obtained it by differentiation, was led to remark its anomalous nature. The same observation was also made by Clairaut in 1731, on an equation of which Taylor's is a particular case, but the nature of the complete integral of an equation being not yet known, that which to Euler was a real paradox, was to Clairaut only "singularité de calcul." Euler, however, contrary to his usual practice, contented himself with delivering rules by which these paradoxical solutions might universally be recognised, without attempting to explain them, (see his *Integral Calculus*, i.) or to shew their connexion with the complete integral. It was reserved for La Place, in a memoir among those of the academy for 1772, to do away the paradox, by demonstrating their necessary origin from the nature of differential equations, and to shew how they might be derived from the differential equation, by means of a very remarkable property of its integrating factor, which is always rendered infinite by that relation between the variables which constitutes a singular solution. Lagrange, resuming the subject in a memoir presented to the academy of Berlin in 1774, discovered the connexion between the singular, or, as they must now be called, particular solutions, and the complete integral, rendering their theory an essential part of that of the arbitrary constants. The subject of particular solutions has since been resumed on a very extensive scale by M. Poisson, but as we have dwelt perhaps too long on the subject, we shall only notice, farther, that the illustration of their geometrical signification, when applied to the theory of curves by Lagrange, forms one of the most beautiful applications of analysis to geometry.

The great difficulty of integrating differential equations in general, and their perpetual occurrence in every application of analysis, has caused every artifice which ingenuity can devise to be tried upon the subject. No one has distinguished himself in this respect more than Euler, whose inexhaustible fertility had here the amplest field to display itself. The methods given by him of completing the integrals of equations from given particular values, seem more promising than most of the attempts that have been made, but the partial success of every inquiry of the kind is, we confess, very discouraging. In one class of equations, however, of the utmost importance in the more profound inquiries in the mixed mathematics, this mode of proceeding in the hands of Lagrange has been attended with more success. This class consists of the *linear* equations, or those in which the dependent variable and its differential co-efficients do not rise above the first degree. These had been treated partially by D'Alembert, in his *Reflexions sur la cause generale des Vents*, when he delivered a very elegant methed of integrating a system of several such equations without elimination, by means of indeterminate factors. This artifice is peculiarly remarkable, as the use of it has grown by degrees very common in analysis. Lagrange, it is curious to observe, has employed it in a very beautiful paper in the 3d vol. of the *Melanges de Turin*, for the solution of a system of algebraic equations of the first degree; and the admirable purpose to which the same profound geometer has applied a similar artifice in the calculus of variations, and in mechanical inquiries, has rendered it one of the most striking features of his method of treating questions. The way in which this and similar delicacies of analysis have passed from author to author, would be well worthy of a more minute examination, as a great deal of the refinement of the modern methods is due to them. The subject of linear equations was likewise to a certain extent discussed by Euler, but it is to Lagrange, as we before observed, that we owe their general theory. The reduction of the integration of a linear equation of the n^{th} order, to the discovery of $n - 1$, particular values which satisfy the same equation deprived of its absolute term, which he has performed in the vol. of the Turin memoirs above cited, (1763-5,) is nearly all that can be hoped for in so complicated and difficult an inquiry. Succeeding authors have added little or nothing to his theory, if we perhaps except Mr. Spence, whose posthumous papers before noticed, contain a system of series for the integration of the whole class in their most general form. It would, however, be doing a great injustice to one of our best mathematicians, Thomas Simpson, not to notice that he also, apparently without knowing that the same step had already been made by Euler, arrived at the integral of the linear equation of any order, with constant co-efficients. It is unhappily but rarely that we have to mention similar coincidences.

The application of analysis to the solution of problems in geometry and the physical sciences, by forcing upon the analyst a perpetual and minute attention to the meaning of his symbols, has given birth to innumerable profound theories, but in no instance has this been more strikingly exemplified than in the discovery of the inverse calculus of partial differences, a discovery which changed the whole face of analysis, and opened a field of generalization, to which all that had gone before was elementary and limited in comparison. The first instance of an equation of partial differences, treated and resolved as such, was given by Euler in 1735, on the occasion of a geometrical problem, but it is to D'Alembert that we owe their first introduction into the mixed analysis, in his solution of the problem of vibrating chords and the *Reflexions sur la cause generale des Vents.* The former of these subjects is eminently calculated to place the peculiarity of their nature in a prominent light; yet it was not till five years afterwards, (1752,) when the same geometer published his *Essai d'une nouvelle theorie de la Resistance des fluides*, that it was seen that those solutions which had hitherto been supposed general were not so, and the physico-mathematical sciences, as well as the pure analysis, assumed a form entirely new.

The integral of an equation of partial differences expresses no single relation between the variables, but a whole class of relations having some peculiarity in common, and hence, even before their discovery, it might have been foreseen that some such calculus would be necessary to embrace physical problems in their generality. In the oscillations of a fluid mass, for instance, or the vibrations of an elastic surface, it is evident that the initial form given to the surface may be perfectly arbitrary, and that its form after the lapse of any time must be in some manner modified by and dependent upon that initial figure; but as the differential equations expressing the motions of their particles can, from their nature, only represent the *change* of motion from instant to instant; it is obvious that their integrals must be of a sufficiently general nature to embrace every conceivable supposition as to the initial state, which could never be the case with ordinary differential equations. This consideration, followed up, might have alone sufficed to point out the calculus of partial differences.

In proportion to the generality of these equations, or, so to express it, the quantity of meaning condensed in them, it may be supposed that their analysis is peculiarly abstruse and difficult. In fact, it is so much so, that although great exertions have been made, and great difficulties overcome, we have not much reason to boast of our progress. Their treatment depends on considerations totally different from those by which ordinary differential equations are integrated, turning principally on the conditions which render a function an exact differential. It has been already observed, that the equations which determine the integrating factor of an ordinary differential equation are of partial differences, and it is on this circumstance that most of the successful attempts (of any generality) at the integration of equations of this latter kind have been founded, by reversing the difficulty, and making the discovery of these factors a prelimanary step towards that of their integrals into which they enter under the form of arbitrary functions, perfectly unlimited, as Euler first observed, in the manner of their composition, and which may even be subject to no analytical law. By this circumstance, more than any thing, we may form an estimate of the small progress which has been made, as, when the difficulties peculiar to equations of partial differences are overcome, we have frequently still to contend with all those which ordinary differential equations present. Yet many particular forms, and even classes of some generality, have yielded to the researches of geometers, among whom d'Alembert, Euler, Monge, La Place, Lagrange, and Biot, have particularly distinguished themselves, though it would be next to impossible, without the introduction of algebraical formulæ of some extent, to enter into any particular account of their labours. We can only allow ourselves one or two observations on their general result. The question as to the number and nature of the arbitrary functions and constants which complete their integrals, which is one of the most important points of their theory, remains involved in great obscurity. It was at first supposed than an analogy existed in this respect between them and common differential equations, but this opinion has been found in every point of view incorrect. Indeed, the most simple considerations of eliminations would suffice to demonstrate this. In one instance, indeed, the analogy holds to a certain extent; La Place having shewn, (*Mem. Acad. Par.* 1773,) that in the case of the linear equations, (to which, on account of their peculiar importance in physical researches, the attention of geometers has been particularly directed,) the arbitrary functions must enter in a linear form into the integral, and his demonstration, which extends only to equations with two independent variables, is easily generalised. But here a difficulty of a strange nature occurs. It may happen, and most frequently does, that it is altogether impossible to represent their complete integrals, (even when we go no higher than the second order,) by any finite combination whatever of these arbitrary functions, and their differential co-efficients; an impossibility inherent in their nature, and in no way depending on its *impracticability* as arising from our limited knowledge. La Place is the first, we believe, who has demonstrated this impossibility, and Biot, resuming the subject in the 4th Vol. of the *Mem. de l'Institut*, has greatly extended this branch of the investigation, and shewn, among others, that the very important equation which expresses the undulations of elastic and of fluid surfaces, and the minute agitations of the air, is in this predicament.

The particular solutions of partial differential equations, too, present anomalies no less striking, and the researches of Lagrange and Poisson, however profound, have as yet but disclosed a part of our ignorance of this intricate subject.

The calculus of finite differences or increments, a branch of analysis scarce inferior to the differential calculus in extent, and peculiarly important on account of the metaphysical illustration it affords of the infinitesimal method, was first treated as a separate branch, and furnished with a peculiar algorithm by Brook Taylor, in his *Methodus incrementorum* in 1715, though the foundation of the method was established, and some of its principal theorems demonstrated by Newton, in his *Methodus Differentialis*.* Its first application was almost exclusively to the summation of series, and indeed the general theory of series, considered as a succession of analytical functions, regulated by a certain law, is still the great object of the calculus of differences in its most refined state; and if, in the hands of some writers, this object has been in a great measure lost sight of, in their eagerness to connect its processes with those of the differential calculus, it has been owing to their not fully perceiving the essential independance of that variable which denotes the place of any term in a series, whose difference is necessarily unity. La Place has well remarked, that the first who summed a geometric progression integrated an equation of differences. This remark applies more distinctly to the discoveries of Demoivre, in his *Miscellanea Analytica* (1730), respecting recurring series, which in the end amount to the integration of the linear equation of any order with constant co-efficients. Stirling too, in a work deservedly regarded as one of the most curious and useful among the older ones on series, (*Methodus Differentialis*, &c. 1730) carried the theory yet farther, by considering series in which the relation between the consecutive terms is expressed by a linear equation with variable co-efficients, expressing the sum in finite terms when they follow a certain law afterwards generalized by La Place, and in other cases resolving it into series of extremely rapid convergence. Emerson too, in 1763, has given a treatise on increments, one of the best of his works, and to which it would be wrong to deny a very considerable share of merit, but which is nevertheless strongly tinctured with that rudeness and confusion of analysis, (especially in what regards equations of differences,) which characterise all his writings. Still the state of this calculus on the continent at that period was in some respects inferior to what appears in this work of Emerson, or even Stirling's, and accordingly it was immediately translated into French.

The direct method of differences was however first put into a general and regular form, and furnished with an algorithm capable of doing justice to its powers, by Euler, but the inverse method was not much extended by him. Lagrange was the first to shew that the equation of a recurring series might be treated by D'Alembert's method of integrating a differential equation with constant co-efficients, and the analogy between the linear equations in both methods, (or rather between the modes of treating them) was a few years after demonstrated by La Place in the Turin Memoirs, (1763-5.) It is to this great geometer that we owe the calculus of partial finite differences, and a succession of profound researches which have changed the whole appearance of the method of differences, and which he has embodied in one vast system, under the name of "Calcul des Fonctions Generatrices," depending on the identity of the developements of the same function, however obtained, and the conseqeent equality of co-efficients of similar powers of its elements in developements obtained by different methods. Nor ought we, among the new and striking views to which the calculus of differences has given rise, to omit those interesting analogies discovered by Lagrange in 1772, between the indices of differentiation and the exponents of powers, an analogy which Arbogast for the first time placed in its true light by the ingenious idea of separating the symbols of operation from those of quantity, and which now points to a calculus of a different kind from any which has hitherto occupied geometers; a calculus whose object is to discover relations between the different kinds of operations which may modify the *forms* of functions, and which may be termed the *Calculus of Derivations*, with much greater propriety than the peculiar mode of developing functions to which Arbogast has limited the name; a calculus, in fine, which we have good reason to assert will be found abounding with relations of a very general and uncommon nature, but which this is not the place to dilate upon.

We are now naturally led to speak of a branch of the differential calculus, which has by degrees swelled to a stupendous magnitude, and though at first but a very subordinate object of it, has at length, in great measure, become identified with the calculus itself. We speak of the developement of functions. Its basis is that theorem, whose discovery by Brook Taylor has done him more honour than any single theorem in the pure analysis has yet conferred, though, were strict justice done, Newton would not be wholly excluded from a share in the discovery, as a scholium added to his *Quadratura Curvarum* in 1704, the year of its publication, will satisfactorily shew.* Be that as it may, the force of Taylor's theorem was so little understood, that, when exhibited in a slightly different form by Maclaurin in 1742, and applied by him to the developement of functions, it was regarded as a new discovery. Since that period, geometers have vied with each other in giving new demonstrations of it; but the only one which is to our purpose to notice, is that of Lagrange.

It would be needless to trace the history of the various lights in which the differential calculus has been exhibited, all more or less dependent on the notions of infinity, or, which is still more revolting to analysis, on mechanical conceptions. Struck with this circumstance, Lagrange conceived, in 1772, the grand idea of rendering this powerful method independent of any principles but those of the elementary algebra, where all the magnitudes under consideration are finite and abstract. This object, the greatest revolution which the nature of a science like mathematics could admit in the principles of its most extensive branch, he a complished, by demonstrating the theorem of Taylor from first and independent principles, *defining* the differential co-efficient of a function to be merely that of the second term of this developement of its varied state. By this means, a strong and unexpected light was thrown over branches of the differential calculus, formerly the most obscure, and a compactness of union between its parts established, which no other way of conceiving it has been found to give. The calculus, too, is thus keep distinct from its applications, and the transition from one to the other made by considerations totally divested of any metaphysical obscurity. These views of Lagrange are to be found in the *Berlin Memoirs* for 1772; in his *Theorie des Fonctions Analytiques;* and, finally, in his *Leçons sur le Calcul des Fonctions.*

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* An inaccuracy in the wording of this scholium shews, indeed, that Newton had not bestowed much pains in following up his idea, though it does not affect the truth of the fact announced. John Bernoulli, with more malignity than wisdom, seized upon this inaccuracy, to prove that Newton did not understand the theory of the superior orders of differentials. He could not possibly have chosen a more unfortunate ground.

The differential calculus, once established on the theory of developements, may legitimately be employed in perfecting and facilitating that theory. The beautiful theorems discovered by Lagrange, and demonstrated and extended by La Place in 1779, by whose help any function may immediately be developed in a series, from an equation in which it is any how involved, shew the extent to which this application may be carried. But the developement of functions has of late been resumed on a yet more unbounded scale, by the aid of what is called among the German analysts, to whom the research has been almost exclusively confined, the *combinatory* analysis. This analysis, which is, in particular, indebted to Hindenburgh for one of its most general theorems, and for its erection into a system, owes its origin to a paper of Leibnitz, in the *Leipsic Acts*, 1700, where he employs the notation of *indices* (which Wallis had, however, long before employed in his *Arithmetica Infinitorum*, with great effect, in the theory of continued fractions,) to discover the law of a certain series of reversion. Its object is to lay down general and regular methods of writing down the terms of the most complicated developements in a convenient order, and without unnecessary trouble, and in this light may very frequently be of the utmost use as a subordinate instrument.—But when we hear its cultivators proposing by its aid to reduce the whole of analysis to mechanical rules, and to a system of writing down letters in horizontal and vertical columns and pages, (*Lexicographically* and *Stelegraphically*,) we think we may venture to predict that those whose taste has been formed on the contemplation of the pure and exquisite models of refinement in symbolic expression which the writings of Lagrange and La Place present, will not easily acquiesce in the superiority of a system whose characteristic feature is the exclusion of all analytical artifice.—Arbogast has considered the subject in a very different and artificial light, in his *Calcul des Derivations* (1800), and his methods, which include in simple and expressive formulæ the co-efficients of the most gigantic developements, seem to unite the two great requisites, elegance and power, in a more perfect manner than could have been expected.

There is no subject where it is more necessary to have recourse to artifices of every kind, to obviate the inconveniencies arising from the multiplicity of terms, which spring up on all sides under the hand of the calculator, and impede his progress by their mere mass, than in the theory of algebraic equations, especially when eliminations of any extent are concerned. In such researches, the multitude of terms branching out in fresh ramifications at each operation, often becomes so overwhelming, that all hope of ever arriving at a final equation would be done away, but for some method of repressing this troublesome luxuriance, and confining the formulæ within manageable bounds. Waring, one of the most profound, but at the same time the most obscure of the English analysts, has given a very beautiful instance of this kind, in his method of exterminating radicals from an equation by the properties of the roots of unity; while his researches, together with those of Cramer and Bezout, have reduced, the problem of elimination, if not to its least difficulty, yet at least to a degree of practicability, which will always enable a zealous calculator to arrive at a final equation of no greater complication than the nature of the case demands. But here his difficulties are but commencing. It may seem strange, that we have so long deferred speaking of the progress and present state of the theory of algebraic equations; but the truth is, the subject is an ungrateful one. On no part of analysis has more profound and pertinacious inquiry been bestowed. and on none with so little success. As far as regards the solution of equations, the problem remains precisely where Ferrari left it in 1540, except that its difficulty is more completely understood. The principal methods which have been proposed, are that of Waring, (commonly regarded as the methods of Euler and Bezout, but which the English author has satisfactorily proved his claim to in his *Meditationes Algebraicæ*,) and that proposed by Tschirnäus in the *Leipsic Acts* for 1638, for taking away all the intermediate terms from an equation. These methods succeed perfectly as far as the fourth degree; but La Grange, in a most masterly analysis, in the *Berlin Memoirs* for 1770–1, has shewn, when applied to that of the fifth degree, they tend to a final equation of the sixth, which seems susceptible of no farther reduction. Yet farther, he has shewn, that all these methods are ultimately the same, or dependent on one very simple transformation; and Vandermonde, who took up the research at the same time, arrived by a different and independent method, of a simple and ingenious nature, at the same conclusion, and, moreover, rendered it extremely probable that this is the only transformation which presents any chance of success. M. Ruffini, adopting the leading feature of Vandermonde's analysis, has even attempted to give a direct proof of the impossibility of representing the root of an equation of the fifth or higher degree, by any finite combination of radicals with the co-efficients. Meier Hirsch, a German analyst of great merit, however, was so little satisfied with this result, that he actually published, in 1809, a general resolution of all equations, founded upon the (supposed) reduction of those final equations at which La Grange and Vandermonde stopped; but he has since acknowledged his error, which we should therefore not have mentioned, had not the work which contains it (*Sammulung von Ausgaben aus der Theorie der Algebraischen Gleichungen*) been in all respects, except this, the best compendium we have yet seen; and though mistaken in supposing that he had found the *general* resolution of equations, he has yet arrived at that of several very remarkable particular cases. It remains, then, to have recourse to series and numerical approximations. The way was led by Newton, in his *Analysis per Æquationes*, &c.; and his method of approximation, when a sufficiently near value can be had to begin with, is perhaps the readiest which can be used. La Grange, however, entering on the subject in an extremely general way, arrived by this path at his elegant theorem of developement before mentioned, which represents at once the value of the root in a series when the equation is a literal one; and in the case of a numerical equation, the same author has propounded a method which, in every case, leads by a direct process, independent of any trials, to approximate values of all the roots, real or imaginary, to any assigned degree of accuracy. It is founded on the theory of continued fractions, a species of series discovered by Lord Brounker in 1655, and has the peculiar advantage of giving the exact values of the roots whenever they are integers, or even surds of certain forms. Happily it is not frequent in physical researches to meet with equations of very elevated degrees, if we except in the method of La Place for discovering the perihelion distance of a comet, which may, in certain cases, lead to one of the 7th.

The rest of the theory of equations, their transformation, and the symmetrical functions of their roots, have been rendered very complete, principally by Waring in his *Meditationes Algebraicæ*, though his methods are often surpassed in elegance and facility by those of La Grange, whose unlimited command of symbolic language has led him to many of the most beautiful results in their theory. Yet the discovery of the number of their impossible roots is still incomplete beyond the fifth degree. It is singular that the general proposition, that *every equation has a root*, should all along have been taken for granted, till Gauss, one of the first geometers now living, after reiterated attempts, succeeded in demonstrating, independently of any tacit supposition of the kind, the resolubility of every polynomial into real quadratic factors.[*]

It cannot be expected, that in this brief and general sketch we should notice all, or nearly all, the ingenious methods devised by geometers for the expression and treatment of abstract questions. Of the calculus of variations we shall presently speak. The subject of definite integrals also is become too considerable to be passed over without notice, holding out, as it does, in the opinion of those most competent to judge, greater promise to future inquirers than almost any other branch of analysis. The foundation of this method was laid by Euler, in his integral calculus, and in a multitude of excellent memoirs in the *Petersburg Transactions* about the year 1775, in which he assigned the values of many integrals between certain limits, which in their indefinite state are transcendents of extreme complexity, and pointed out several remarkable relations to facilitate the calculations of others, which Legendre has since systematically embodied and extended in his *Exercises*, &c. The subject was pursued by most geometers of eminence. Mascheroni, in his *Annotationes in Calculum Integralem Euleri*, (1790,) has considered a vast number of forms of definite integrals, and treated the subject with great success. He, however, fell into some errors, which La Place pointed out in the 15th Number of the collection of the *Ecole Polytechnique*; but which M. Bidone, in a very ingenious paper among the *Mem. Turin.* 1811–12, has shewn to be mere oversights, as the very same method with that pursued by Mascheroni, when conducted with proper circumspection, leads, in his hands, to the true results, as well as to a variety of remarkable relations, before unknown. The most usual and general methods employed in the valuation of definite integrals, are,

1*st*, The reduction of certain factors under the integral sign into series, by which the transcendent is reduced to others of a known form.

2*d*, Differentiation and integration relative to some of the *constants* involved in the function under the integral sign, by which one definite integral being known, others may be derived from it. This is a favourite artifice of Euler.

3*d*, The passage from real to imaginary forms of the variable, and the limits of the integral. This transition, which is of peculiar delicacy, and requires the nicest analysis, was first employed, if we mistake not, by La Place, with remarkable success, in a most profound theory published among the *Mem. de l'Acad.* 1778, 1782, and which, with several subsequent additions published at different times in the *Journal de l'Ecole Polytechnique*, the *Nouveau Bulletin des Sciences Philomathiques*, &c. he has lately digested into a regular system, connecting it with the calculus of generating functions, in his admirable work, the *Theorie Analytique des Probabilités*, a work of which it will not be too much to say, that it may be regarded as marking the highest point to which the science of abstract magnitude has yet attained.

The transition from real to imaginary quantities, however carefully conducted, necessarily involves some obscurity; and it is at least satisfactory to know, that the same results may be deduced without its aid, though by more circuitous processes. This is the object of a very excellent memoir of M. Plana, in the volume of the Turin Memoirs for 1816, where he has shewn that several of the most important results of this method, and in particular one very remarkable one discovered by Legendre, may be obtained by one or other of the other methods above enumerated: At the same time, this able geometer has added largely to our knowledge of the subject, exhibiting several new and very elegant forms. The labours of M. Poisson, too, in this field ought not to be forgotten. The memoirs of this truly profound analyst are full of interesting information on the subject, either incidentally presented, as in the case of those extraordinary forms in his second memoir on the distribution of electricity, and a variety of others, or systematically digested. See his admirable paper *Sur les Integrales Definies*, *Jour. de l'Ecole Polytech.* ix.

It is the application of definite integrals to the evaluation of functions of very high numbers, and to the integration of equations of finite and of partial differences, which gives the subject its interest, and seems likely to raise it, at no distant period, to the highest rank in the scale of analytical importance. It is no uncommon case, especially in the application of analysis to the doctrine of chances, to obtain a final result requiring for its computation only the most ordinary rules of arithmetic, but involving numbers of such enormous magnitude, that the utmost patience of the most laborious calculator would shrink from the task. Results of this kind present all the difficulties of the most complicated transcendents in their evaluation, and it becomes indispensable to resort to some method of approximation which, while it grasps the prominent part of the result in a formula of easy computation, may throw the rest, as it were, into the back-ground, in the form of a rapidly converging series, connected with the foregoing as a factor. Stirling gave the first example of the kind, in his approximation to the middle term of a binomial raised to a high power. Not long after the indefatigable Euler, whose attention seemed directed at one instant to every part of mathematical science, discovered a general method for the summation of series by means of an integral and a rapidly converging series, (*Com. Petrop.* 1736,) which, at the same time that it afforded a direct and luminous demonstration of Stirling's theorem, (as the same geometer afterwards more fully shewed, in his *Inst. Calculi Differentialis*, 1755,) opened the way to those more general considerations of the analogy between the exponents of powers and those of differentiation and integration which La Grange discovered in 1772, and which we have already noticed. But by far the most extensive views of this most interesting subject are those taken by La Place in his two memoirs of 1778 and 1782, already noticed, and in the first part of the *Theorie Anal. des Probabilités*. The general principle on which his inquiries proceed, is to regard the functions under consideration as arising from certain equations of differences, which, by the substitution of an indeterminate integral, and a happy application of that useful artifice, the integration by parts, are divided into two, one of which determines the *form*, the other the *limits*, of the integral. A similar artifice applies with success to many of the most intractable equations of partial differences, as well finite as infinitely small, or even of mixed differences. Parseval, whose beautiful theorem for the summation of series by a definite integral is known to every geometer, has shewn, among others, that the equation representing the propagation of sound in an atmosphere of three dimensions, is among this number: but the difficulties which remain to be overcome, owing to the intractable form of the integrals so obtained, (even in cases which yield completely to other methods,) are yet very great, and justify us in dismissing the subject as one which, however considerable the progress already made in it, must await its perfection at the hands of future geometers.

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[*] His demonstratio *nova* depends on the *geometry of situation* The *novissima* I have not seen.

While these great steps were taking in the pure analysis, every advance drew after it a corresponding improvement in its applications. Indeed many, if not the greater part of the analytical methods have been indebted more or less for their origin to that succession of difficult problems which were discussed by Leibnitz and his followers during the early part of the 18th century. Such were, besides those already mentioned, the problem of the trajectories, or curves which cut an infinite number of others at a given angle, which, as we have seen, led Nicholas Bernoulli to the discovery of the first equation of condition, and therefore may be regarded as having opened the way to the partial differential calculus. The problem of the tautochrone in a resisting medium might deserve a more particular history than our limits will allow us to devote to it, being one of a peculiar and delicate nature, and having exercised the ingenuity of nearly all the first geometers. Huygens first demonstrated the tautochronism of the cycloid in vacuo, and was followed by Newton, who extended this property to the hypothesis of a resistance, constant, or proportional to the velocity. The first direct solutions, however, of the problem of tautochrones were those of John Bernoulli, *Acad. Par.* 1730, and of Euler, (iv. *Old Petersb. Comment.*) which, however, are of little use, as they require that the expression of the velocity should be known. Fontaine, in 1734, by employing what he called the *fluxio-differential calculus*, in which the same quantity is supposed to vary in two different manners, (being in fact not very different from that used by Leibnitz and the geometers of the 17th century for the problem of projectories,) gave a solution which appeared so satisfactory, that "*on ne parla plus des Tautochrones.*" La Grange, however, was not so easily satisfied. In 1767, he read a memoir to the Academy, which re-awakened the attention of geometers, and gave occasion to Fontaine to publish a somewhat angry refutation, which would not be worth our notice, had it not produced a second memoir from the pen of La Grange, which may be regarded as final upon the subject, at once demonstrating the insufficiency of Fontaine's solution and including in general formulæ all the practicable cases of the problem. In this memoir of La Grange, (which appeared in the Berlin Memoirs for 1770,) he takes occasion to annul Fontaine's claim to the discovery of the equations of condition, and to assign it to Nicholas Bernoulli, its proper author. The problem too of the quadrable spaces of curves, and curve surfaces, (among which is the famous Florentine Enigma proposed by Viviani in 1692,) as well as those of rectifiable algebraic curves, deserve notice, as having given rise, in the hands of Euler, to a kind of indeterminate integral calculus of a very singular nature. Indeed the theory of curves, though solely dependent on analytical transformations, yet, on account of the relief it gives to subjects of abstract speculation, and the assistance it offers to the imagination in interpreting the peculiar combinations of symbolic language, has ever proved a most valuable guide to geometers. There is nothing which sets in so clear a light the great analytical *law of continuity*, and the passage of a function in succession through all its possible gradations of magnitude. Nor ought the superior degree of interest which is apt to be excited when our speculations are seen to have some immediate bearing, some hold as it were on the reality of things, to be wholly left out of the account.

The first fruits of the differential calculus applied to geometry, consisted in general methods for drawing tangents, finding radii of curvatures, &c. and determining the areas, lengths, and other particulars of curves, all which, though now familiar in every elementary work, were, in their turn, subjects of more or less discussion. Indeed the theory of the cusps and other singular points of curves could not be said to be rightly understood till Maclaurin, in his admirable *Treatise on Fluxions*, (1742,) by applying Taylor's *Theorem* to the subject, and bringing into account the parts of the curve immediately adjacent, first furnished a sure and unequivocal criterion for distinguishing their different species from one another.

Curves of double curvature and curve surfaces were not wholly unknown to the ancients, though always looked upon as *altioris indaginis*. The Cartesian geometry opened the way to their discussion with the same facility as that of plane curves; yet it was not till 1730 that Clairaut first entered systematically on the subject, in his *Treatise on Curves of Double Curvature*, a work which, published at the early age of sixteen, shewed what one day might be expected from him. This branch of geometry, with that of curve surfaces, with which it is inseparably connected, was pursued by Hermann, Bernoulli, and Euler, the latter especially, carrying the examination of their theory to a very considerable extent. To him we owe the determination of the curvatures of different sections of curve surfaces, their sections of greatest and least curvature perpendicular to the surface at any point, the characters by which it may be known whether a curve surface is capable of developement, or unfolding into a plane, &c. (*Mem*

Berl. 1760.—*Nov. Com. Pet.* xxi. 1768-9.) To no one, however, is the geometry of curve surfaces more deeply indebted than to Monge, whether we regard it in an analytical or geometrical point of view. By combining the theory of partial differential equations with that of the curve surfaces they may be supposed to represent, and considering the mode of their generation with relation to such equations, he may almost be said to have created for himself a new method of investigation, in which geometrical considerations are made to supply the place of analytical processes, even in subjects which seem most peculiarly under the dominion of the latter method, and which he has applied with singular success, not only to interpret, but to integrate such equations.

Analytical geometry, however, properly so called, which proceeds upon the sole consideration of the data of the question put into symbolic language, making no preparatory constructions, and either dispensing altogether with the use of diagrams, or employing them merely to assist the imagination in its conception of the data,—geometry, in this state, is due solely to La Grange. That great man, in his memoir on Pyramids, (in the *Berlin Mem.* for 1773,) first shewed the practicability of treating the most complicated questions of solid geometry in this way; and, what is very remarkable, this mode of proceeding, instead of inducing obscurity, as might at first be expected, is remarkable for the luminous and distinct conceptions it gives of geometrical questions. The principal reason of this is, the extraordinary symmetry which symbolical expressions, properly constructed, assume in geometrical inquiries. This it is which renders them easy of management, and at the same time facilitates their interpretation into geometrical language in a remarkable degree, rendering it indeed so obvious, that it may generally be carried on as a collateral process with the algebraic reasoning. There is no author whose writings furnish more striking and beautiful examples of this symmetry in his formulæ, which speaks to the eye, and enables us almost to predict the results without executing the operations required, than La Grange. Those whose inquiries have been confined within what we may now fairly call the narrow circle of the ancient geometry, may reject, as artificial, such means of discovery as depend rather upon dexterity in the management of symbols, than on that direct contention of mind they have been accustomed to consider as inseparable from the abstruser parts of it; but to one familiar with the difficulties with which modern inquirers have to contend, and whose object is only to multiply the number of known truths, and to arrive at results by the shortest and least troublesome path, it will be quite superfluous to enter into any defence of the method which is now universally adopted. If the general idea of Descartes, which reduces the nature of every curve to an algebraic equation, has been the source of all the power which analysis possesses in geometrical inquiries, that of determining the position of every point in space by co-ordinates at right angles to each other, which Maclaurin first brought into general notice, by shewing its utility in physico-mathematical researches, has proved the origin of all its refinement. Any other method might be employed, and a departure from this has sometimes led to very beautiful results; the determination of points in space by their distances from fixed points, or from one another, for instance, has been applied with great success by Carnot, in his *Geometrie de Position*, to the theory of regular and irregular solids bounded by planes; and his labours have been rewarded by the discovery of a vast number of singularly beautiful theorems of pure geometry. La Grange, in a very remarkable memoir on the theory of the planetary perturbations in 1772, has attempted to apply this mode of representation to that difficult inquiry; but though the attempt exhibits an extraordinary instance of the fertility of his genius, and the elegance of his analysis, the equations so transformed, are less simple and symmetrical than those in which rectangular co-ordinates are used. The *Mecanique Analytique* of this great geometer, is replete with instances of the power of symbolic language in representing purely geometrical conditions. This subject has been much and very deservedly cultivated in France, and has of late been exhibited in a very systematic and complete form, by La Croix, in the first volume of his great work on the differential and integral calculus: A work it is impossible not to recommend in the strongest terms to every reader who would wish to see nearly the whole of what is essential in analysis, as it stands at present, brought under his view by the hand of a perfect master in the art of compilation.

Conscious of the advantages to be derived in all applications of analysis, from uniformity of investigation and simplicity of principle, it was not to be supposed that when its language had attained some perfection, geometers would allow any considerable class of problems to remain, which demanded a peculiar mode of treatment, such as that which Euler and the Bernoullis had applied to isoperimetrical questions. There was something in the idea of breaking up an integral expression into its elementary particles, and examining them by parcels, which (to use La Grange's expression,) destroyed the whole mechanism of the integral calculus, and rendered it necessary either to seek some new foundation for that calculus, or to devise a mode of treatment more consonant with the ordinary course of analysis. The processes of Euler, as we have seen in the article Isoperimetrical Problems, were after all incomplete, and it was expressly to remedy these inconveniences, and supply these deficiencies, that La Grange, in 1760, invented his calculus of variations. This calculus, the first, as it was one of the greatest discoveries of its illustrious author, may be described as having for its general object, the estimation of the changes which functions (and in particular, integrals and implicit functions,) undergo by arbitrary and infinitely small variations, either in the magnitude of the quantities, or (which gives the calculus its peculiar character,) the form of the functions on which they depend. The solution it afforded of the problems which gave it rise was so complete, that it would be vain to look for any thing farther, while its powers extended far beyond these limits, bearing nearly the same relation to this particular application, that the differential calculus does to questions of ordinary maxima and minima. There is, perhaps, in the whole history of science, nothing in a moral point of view so sublime, we may say so affecting, as the conduct of Euler on this occasion; it is one of those traits of intellectual nobility which shed round a character a glory surpassing that of any scientific discovery. Standing, as he then did, by universal suffrage, at the head of mathematical science, into every part of which he had pushed his inquiries with a success unknown before—distinguished beyond any geometer before or since, for the inexhaustible fertility of his invention, he had lavished on this one subject, with peculiar complacency, all the resources of his genius, and at length, after years of laborious investigation, might congratulate himself on seeing all his difficulties vanish before him: Yet no sooner did a young, and till then almost unknown individual, propose a method which, though grounded on one of his own remarks, had for its avowed object to supersede all his processes, and render obsolete the result of so much labour, leaving them, like those of Cavaleri, Fermat, and Wallis, before the invention of the differential calculus, no place but in the history of science—then we find him, without a moment's hesitation, acknowledging the superiority of his rival, throwing aside his own methods, and bending his whole attention to the study and elucidation of the new calculus. Euler immediately composed several memoirs upon the subject, in one of which is contained that fundamental idea which La Grange himself, after many attempts, adopted, as the means of connecting the calculus of variations with his peculiar views of the differential calculus. (See VARIATIONS.)

We have purposely avoided to speak of the almost innumerable applications of mathematics, as it would lead us too far, and their history falls more properly under their peculiar heads. The great problems of mechanical philosophy, however, have exerted so striking an influence, not only in exciting the ingenuity, but in directing the researches of the abstract speculator, that we cannot close this article without noticing some of the principal steps by which calculation has been applied to such subjects, and the progressive improvements which the mode of treating them has undergone. The theory of statics, as far as relates to the equilibrium of a single point, may be considered as completely reduced to mathematical investigation by the discovery of the composition of forces as distinct from that of motions. This principle, which was formally propounded about the same time by Newton, in the *Principia*, and by Varignon, in his *Projet d'une Nouvelle Mécanique*, but the substance of which is to be found in a work of Simon Stevin, of a much earlier date, (*Hypomnemata Mathematica*, 1605,) always furnishes conditions which, either by geometrical construction or analytical treatment, suffice to determine the position of the point, or the relation of the forces in the case of equilibrium. In more complicated cases, either the rigidity of the system, or the assumed principle of virtual velocities which Galileo had observed to hold good in certain cases, and which his followers, by an over-hasty and most unphilosophical generalization, extended (without proof) to all, was called in. John Bernouilli, in 1717, was the first who could justly be said to *know* the great generality of this principle, and pointed out its use in the solution of problems. It was soon after applied by Varignon, in his *Nouvelle Mécanique*, to a great variety of questions, (1725,) and after undergoing various transformations in the hands of Maupertuis, Euler, and Courtivron, became at length, in those of La Grange, the connecting link between the mechanical considerations of the doctrine of equilibrium, and the analytical processes of the calculus of variations, and in consequence the foundation of analytical mechanics. It must be allowed, however, that neither in point of evidence nor simplicity is it calculated for a first principle; and though the geometer last mentioned, in the second edition of his *Mécanique Analytique*, has given a most ingenious and general demonstration of it from the property of the pulley; yet the course pursued by La Place, in the introductory chapters of the *Mécanique Céleste*, setting out from the composition of forces, and thence deducing the principle of virtual velocities in all its generality, as a convenient transformation on which to ground the analytical artifices of the science, seems more natural; though the transition from the equilibrium of a material point to that of a system in the latter method, requires some steps which are avoided by the former.

The equilibrium of fluids was a subject of much greater difficulty. Even Huygens and Newton had erred in their estimate of the conditions necessary for its establishment, in the important problem of the figure of the earth. To those proposed by Newton, Maclaurin added others, in his theory of the equilibrium of a revolving spheroid, which shared the prize of the French Academy in 1740; a theory which it will scarcely be too much to regard as exhibiting the most perfect specimen of the geometrical method of investigation in the mixed sciences yet produced. It was Clairaut, however, who, taking up the subject in a more general point of view, stated it as a necessary condition, that every canal of single or double curvature terminating in the surface, or re-entering into itself, should be separately in equilibrio, in virtue of the forces which solicit it—a condition which Robison (in his *System of Mechanical Phil. Astron.* 474) has indeed shewn to be included in Maclaurin's, in the case of an homogeneous fluid; but this limitation is unnecessary, and Clairaut was the first to derive from his condition, the correct and general laws which regulate the equilibrium of a fluid mass acted on by any forces, and to point out their connexion with the equations of condition which render a function an exact differential. In the Berlin Memoirs, 1750, Euler deduced the same laws more simply from the necessity of a particle at any depth being equally urged in opposite directions, in virtue of the acting forces, and the *quaqua-versum* pressure of the fluid. This latter principle, on which depends the "Hydrostatic paradox," was demonstrated by Stevin, in the work above cited, by supposing the rigidity of a part of the fluid; but it was reserved for La Grange to shew, by a very refined analysis, the necessary connexion of this property with the internal constitution of a fluid regarded as an assemblage of independent and perfectly moveable molecules kept at a distance from one another by their mutual repulsion, and thus to reduce the equilibrium of fluids to precisely the same principles with that of solids.

The motion of a material point in free space, under the influence of accelerating forces, is a problem which the principles laid down in the Principia are fully adequate to reduce to the differential equations on which its solution depends. This, it is true, is not the course pursued in that immortal work, the synthetic methods there followed admitting no direct investigation of the kind—but the differential calculus under the form of prime and ultimate ratios is perpetually employed, and the immediate followers of Newton did not hesitate to make such use of the algebraic calculus, and the inverse methods, as their improvements in analysis from time to time admitted, in consequence of which a number of dynamical questions, relating to the motion of bodies round centres, or in resisting media, were treated analytically with complete success. But there were yet difficulties of a higher kind, difficulties in principle, to be surmounted before mechanical problems could be regarded as completely reduced to mathematical investigation. About the period from 1736 to 1743, the Bernoullis, (John and Daniel,) Clairaut and Euler, had kept up an interchange of difficult problems on the motions of bodies connected with each other or with fixed obstacles, or otherwise constrained in their natural directions—problems rendered interesting at once by their singularity and the want of a general principle for their solution. That of the conservation of active forces (*virium vivarum*,) proved of eminent use in these inquiries. It was first set up without proof by Huygens, on occasion of the problem of the compound pendulum and centre of oscillation; but though an exact solution was obtained by the use of it, John Bernoulli was the first who gave a logical one, and being thus led to trace more carefully the secret process which takes place on the communication of motion from particle to particle, anticipated in some measure the meaning, if not the general enunciation of that famous principle which would alone have immortalised the name of D'Alembert, and which put a final end to all difficulties in the science of Dynamics, by reducing all its problems to equivalent cases of equilibrium. (See MECHANICS, PRINCIPLE *of D'Alembert*.) This was laid down for the first time by its author, in 1743, in his *Traité de Dynamique*, and though a great degree of obscurity and unnecessary complication reigns throughout his own applications of it, was soon found to furnish with the utmost facility the means of including every dynamical problem in its proper equations. The principle, as it is now usually stated, appears of such elementary simplicity, that we wonder it should ever have proved of such momentous importance; and it is only when we know that men of the greatest genius were embarrassed by difficulties of which, in consequence of it, we now hear no more, that we can be brought to estimate its value. It is, in fact, a striking instance of the influence the manner of wording an obvious truth may have on its applications. A rigorous solution of the great problem of the precession of the equinoxes, and an exact theory of the motion of fluids, disencumbered of every hypothetical restriction, were the first fruits of this capital step. Hydrodynamics was a science unknown to the ancients, and it was only in the hands of Newton that it first could claim the title. The empirical law of Torricelli, for the velocity of a fluid flowing from a large vessel through a small orifice, engaged that great geometer to undertake its demonstration, in which it must, however, be confessed, he fell into a strange and very obvious mistake in principle. His comparison of the motion of waves to that of a fluid oscillating in a canal, though less obviously erroneous, was in point of fact not much more happy. Varignon gave a more legitimate explanation of Torricelli's law, which in the extreme case contains the true theory. The opposite extreme of fluids running through pipes, was treated by Daniel Bernoulli in his *Hydrodynamique*, (1738,) by the principle of the *vis viva*, and his analysis is remarkable for its elegance. The principle of D'Alembert, however, having furnished that geometer with the means of reducing all dynamical problems to equivalent statical ones, and the equilibrium of fluids being at the length completely understood, this noble application presented itself at once, and he was thus enabled to include the whole theory of fluids, as well elastic and compressible as the reverse, in equations rigorously true, and dependent on no simplifying supposition or case of ease. This great step was taken on occasion of a prize proposed by the Berlin Academy on the resistance of fluids, in 1750, and in his essay on the same subject, in 1752. His equations, however, yet wanted something in point of simplicity, and even generality; and it is to Euler we owe the first completely general formulæ for the motions of fluids, founded on the laws of their equilibrium, and expressed in the simple and luminous notation of partial differences. It is true these equations are of the most intractable kind; but we are at least certain, that whenever the problem under consideration is susceptible of a rigorous solution, they will of necessity be integrable of themselves, and that in all other cases the most direct, nay the only method of approximating to the truth, will be to have recourse to them, however unmanageable they may be.

By such steps the application of the analytical methods to dynamical problems was now become familiar. Geometrical constructions were still resorted to, to obtain expressions for the forces, to resolve them in suitable directions, and even in some cases to estimate their momentary effect; but this done, the inverse methods of the differential calculus were almost universally resorted to as the means of obtaining a final solution either rigorously or approximately true. The way was thus at length laid open to a more extensive resumption of the great problems of the celestial motions, which for 40 years had remained nearly in the state to which Newton had brought it in his lunar theory, (which appeared in David Gregory's *Astronomy* in 1702, and was afterwards transferred to the second edition of the *Principia*,) if we except the labours of a few very respectable commentators of the latter work. To forsake the methods of so profound a master, and enter upon a field which promised to present the most discouraging obstacles, was an idea which none but a very superior genius could entertain for a moment. It was in 1743 (a year, as we have seen, for ever memorable in the history of dynamics) that Clairaut turned his serious attention to the study of Newton's lunar theory, from which, not finding the satisfaction he desired, he at length ventured to abandon altogether the geometrical mode of approximation there employed, and commit himself entirely to the guidance of the symbolic analysis. Already, towards the latter end of 1746, he had obtained the differential equation of the lunar orbit, and integrated it by a first approximation in the simplest state of its perturbations, by employing the expressions of the tangential and normal forces he had obtained in his first inquiries. By a coincidence which marked at once the ripeness of the subject for investigation, and the uniform operation of the instruments they employed, Euler and D'Alembert separately undertook the analysis of the "problem of three bodies," in the same year (1747) in which Clairaut's memoir appeared, and, as well as that geometer, were separately led (by a peculiarity in the problem of which they could not then be aware, and which renders a first approximation to certain among the lunar inequalities insufficient) to results differing so widely from those of observation, that even a doubt of the Newtonian law of attraction began to be entertained. Clairaut, the first to express this doubt, was the first to obviate it, by pushing his approximation to a greater length; and finding himself again supported by an independent investigation of Euler, a full reliance on the law of attraction was produced, and the greatest ardour infused into the inquiry. Without tracing the farther progress of the lunar and planetary theory, it is to our purpose to remark, that the characteristic traits of genius of these great geometers may be clearly discerned in their researches about this time. The analysis of Clairaut is that of a profound calculator, bent on useful applications—pursuing his end by the most direct means—and with little artifice or solicitude about the neatness of his formulæ, provided the numerical exactness of the results be insured. The choice of his co-ordinates, and his manner of resolving the forces, are not the most convenient; yet such was his talent for practical applications, that he alone, of those who have occupied themselves with the inquiry, lost none of his labour, and, pursuing one leading train of substitution and reduction, made all his earliest researches subservient to his more matured views. D'Alembert, a man of extreme acuteness and subtlety of reasoning, possessed a peculiar talent for comparing and estimating methods—a kind of intuitive insight into the advantages and disadvantages of the various lights in which a subject might be considered—and a power of predicting, as it were before-hand, the effect of a long train of analytical operations. A severe and unsparing critic of the methods of others, and of Clairaut in particular, he was yet not peculiarly happy in exposing his own, (which were generally excellent in their principle and conception;) and in his mathematical writings, the classical elegance of his language is often strongly contrasted with the obscurity and want of symmetry of his analysis. In reading his investigations, there is usually much mechanical labour required to perform his operations, and yet more intellectual effort to pursue his reasonings; while in this particular research, he seems to have wanted patience and perseverance in following up the application of even his most striking ideas, and, in consequence, to have missed some of their most important inferences.

A happy medium between the defects—we ought rather to say combination of the excellencies of these very opposite geniuses, and endowed with perfections peculiar to himself, was Euler. Of his admirable qualities as a man, we have already seen a striking instance. As a mathematician, to all the perseverance of the most determined calculator, he united a vastness of conception which the wildest speculator might envy, and a restless activity and variety of inventive power, of which human nature has perhaps afforded no other instance, and which never left him at a loss for means to accomplish his immediate object, though he occasionally suffered himself to be hurried aside by it from the steady pursuit of his more remote one. There are few of the great ideas which have directed succeeding analysts in these difficult researches which Euler did not first strike upon, or at least divide the merit of their invention. The first introduction of the rectangular co-ordinates into the analytical theory of the celestial motions, which Maclaurin had employed with such elegance in his geometrical methods, was made by him in his memoir of 1753, on the lunar theory; and the method of the variation of the arbitrary constants, expanded afterwards by La Grange into so sublime a theory, likewise occurred to him among his first ideas. His extreme modesty in advancing no claims to what was strictly his own, and the harshness, not to say injustice, with which he invariably judged his own methods, ought to render us doubly careful in attributing to him his due share in every improvement.

Clairaut was the first who observed the connexion of those general propositions, which, under the names of the conservation of areas, of active forces, and of the motion of the centre of gravity, had long rendered such assistance in dynamical inquiries, with the differential equations of a body's motion; thus reducing them to their true place in a philosophical arrangement of knowledge, and preparing the way to a systematic analysis of the motion of a body acted on by any forces whatever. This he did in a little memoir, inserted in the *Journal des Savans* for August, 1759. It is true his analysis is directed more immediately to the problem of three bodies; but the artifice by which he combines the differential equations of their motion, so as to obtain the integrals expressing these laws, is applicable in general, and though now familiar to one ever so little acquainted with the subject, must be regarded as very ingenious for a period, when symmetry in the management of symbols was not so much attended to as it has since been. Clairaut died in 1765, in the vigour of his faculties; but the time was long gone by, when the progress of science could be retarded by the loss of an individual, however distinguished. A more consummate analyst than Clairaut,—a more profound reasoner than D'Alembert,—a more comprehensive genius than Euler, and though less exuberantly inventive, more perfect and effective in his inventions, had now commenced his career. Already in 1764, (in a *Memoir on the Libration of the Moon*,) Lagrange had begun to avail himself of that powerful principle of virtual velocities, whose history we have already traced. A fresh impulse seemed now to have been given to science, and from this period scarce a year passed unsignalized by some new and important discovery in the system of the world; and by the emulous but united labours of Lagrange and Laplace, the state of mechanical science was by degrees brought to that pitch of perfection in which such works as the *Mécanique Analytique* of the former, and the *Mécanique Celeste* of the latter, could exist and be appreciated. The first of these immortal productions, which appeared in 1788, (precisely a century after Newton first rendered dynamics a science,) is a compendium of the general formulæ and analytical artifices necessary for the treatment of every problem which can be proposed on the equilibrium or motion of matter. The principle of virtual velocities, translated into an equation by means of the calculus of variations, and extended by the help of D'Alembert's principle to cases of motion as well as rest, is made to afford a simple and expressive formula, embracing every effect the agency of mechanical force, under whatever variety of combinations, can produce. A uniform train of analytical processes is then exhibited, adapted to the particular cases of the greatest importance or most frequent occurrence, by which the consequences of this fundamental equation are developed in succession, and reduced, *en derniere analyse*, to the equations of total or partial differentials, on whose integration the solution of the problem radically depends.

In filling up the great outline which the *Mécanique Analytique* presents, the genius of successive generations may yet be exhausted. In this honourable task, the great names we have just mentioned stand indeed foremost, but not alone. The spirit of research seems to have gathered strength with every new advance, and the recent memoirs of a Poisson, a Biot, and an Ivory, have shewn, that the broad foundation thus laid bids fair to be completed by an answerable superstructure; and that even difficulties of analysis, till lately looked upon as insuperable, may be directly contended with and overcome. For a knowledge of their labours, however, we must refer to the different academical collections of which they form a part, as it would be entirely inconsistent with our plan to enter into any account of them.

An enumeration of the writings even of the chief mathematicians could not be compressed in any ordinary limits. In the preceding pages, we have already pointed out the most important works to the notice of the reader, while those elementary and other works which contain the most exact or comprehensive view of the several branches of the science, will be found enumerated at the end of their proper articles: For those, however, whose taste and pursuits lead them to require a more detailed account of mathematical bibliography, we cannot do better than refer them to the *Repertorium Mathematicum* of Reuss, in which will be found nearly every memoir in academical collections, or treatise of any consequence, arranged under their several departments. Meanwhile, for the convenience of our readers, we subjoin the following table of reference to the various articles on the Pure Mathematics contained in the present work.

Algebra.
Analysis.
Arithmetic.
Arithmetic of Sines.
Chances.
Conic Sections.
Curves.
Fluents. See Fluxions.
Fluxions.
Functions.
Geometry.
Imaginary Quantities.
Interpolation.
Isoperimetrical Problems.
Locus.
Logarithms.
Notation.
Numbers.
Porisms.
Series.
Transcendents.
Trigonometry.
Variations.

Under these heads the reader will find the various branches of mathematical knowledge treated as fully as could have been expected in a work like ours. Those who wish to investigate these branches of Pure Mathematics more profoundly, will find under the different articles the most copious references to the various works which have been written on the subject. (J. F. W. H.)

MATLOCK is the name of a village and parish of England, in the county of Derby. The village is finely situated on the eastern bank of the river Derwent, which is crossed by a neat stone bridge. It is built of stone; and the church, consisting of a nave, side aisles, and a small chancel, is situated at some distance from the village, on the verge of a romantic rock. The chief manufacture is that of cotton, the inhabitants being principally employed in the neighbouring lead mines.

Matlock Bath is beautifully situated on the west side of the Derwent, about a mile and a half south-south-west of the village. In 1698, when its warm springs began to excite attention, the place was occupied by the cottages of a few miners. The original bath was then built, and also a house for the accommodation of visitors. A stone bath and lodging-house were afterwards erected upon the discovery of a second spring, at the distance of a quarter of a mile from the first; and a third bath and lodging-house were erected when a third spring was found at a later period. These buildings are elegant and commodious, and are respectively called the Old Bath, the New Bath, and the Hotel; and, along with a few private lodging-houses, they are capable of accommodating more than 500 persons. The Matlock season begins about the end of April, and continues till November.

For farther information respecting the waters, &c. of Matlock, see our article Derbyshire, vol. vii. the *Beauties of England and Wales*, vol. iii. p. 504; Pilkington's *View of the Present State of Derbyshire*, Derby, 1789; and Bray's *Sketch of a Tour in Derbyshire*, London, 1783.

MATTER. See Boscovich's *Theory*, and Metaphysics.

MAUPERTUIS, Peter Lewis Moreau de, an eminent French mathematician and natural philosopher, was born at St. Malo on the 28th September, 1698. After receiving a private education, he was sent, at the age of 16, to the college of La Marche at Paris, where he evinced an ardent love of mathematical learning, and had the good fortune to receive instruction from M. Guisnée, of the Academy of Sciences. In the year 1718, he entered the regiment of musketeers, and two years afterwards he obtained a company of cavalry in the regiment of La Roche Guyon, which he held for three years. From his great fondness for mathematical pursuits, his friends advised him to devote himself entirely to the sciences; and he accordingly resigned the profession of arms, and was received into the Royal Academy as adjunct geometer, on the 11th December, 1723. On this occasion he read his first memoir, entitled *Observations sur la forme des Instrumens de Musique.* His attention was now entirely directed to mathematics and physics; and in the Memoirs of the Academy for 1726, 1727, 1728, 1729, 1730, 1731, 1732, 1733, 1734, and 1735, he published a succession of memoirs on mathematical subjects, and on the figure of the earth and the other celestial bodies.

In 1728, he paid a visit to England, and became a zealous admirer of the Newtonian philosophy; and during his stay in London, he was elected a Fellow of the Royal Society. After he returned to France, he made an excursion to Basle, where he formed an intimate friendship with the celebrated Bernoulli, the great ornament of that ancient city. He was appointed associate of the Academy in 1725, and pensionary in 1731.

In the year 1736, the king of France placed him at the head of the academicians who were sent into Lapland to measure an arc of the meridian, for the purpose of determining the figure of the earth. This operation was finished in the course of a year, and gained our author such reputation, that he was elected a member of most of the learned societies of Europe.

In 1740, the king of Prussia invited him to Berlin, and he arrived when the king was at war with the emperor. Maupertuis followed his master into the field, and attended him during his war with the emperor of Germany. At the battle of Molwitz, before victory had declared itself in favour of the Prussians, his horse ran off with him into the ranks of the Imperialists, where he was taken prisoner and stripped by the hussars. When he was carried to Vienna, he was received in the most honourable manner by the emperor, and having expressed regret at having been deprived by the hussars of an excellent chronometer, made by our celebrated countryman Graham, the emperor immediately presented him with one by the same artist, but enriched with diamonds, and said, "The hussars were only in jest. They brought me your watch, which I now restore to you." After being loaded with favours by the emperor and empress, he returned to Berlin In 1742, he was made director of the Academy of Sciences; and in 1743, he was elected one of the 40 members of the French Academy; and he had the honour of being the first who was at the same time a member of both the Parisian academies. Having again assumed the character of a soldier, he was present at the siege of Fribourg, and was appointed by the Marshal Coigny and Count d'Argenson to carry to the king of France the account of the surrender of that citadel.

In 1744, Maupertuis returned to Basle, when a marriage was negotiated between him and Mademoiselle de Borck, a lady of great beauty and accomplishments, who was nearly related to M. de Borck, minister of state. Frederick the Great appointed him, in 1746, president of the Royal Academy of Sciences; and he was soon afterwards made a chevalier of the Order of Merit. Amid these preferments, Maupertuis still continued his studies with ardour, and directed his attention not merely to mathematics and physics, but to chemistry, botany, metaphysics, and polite literature.

In the *Memoirs of the Berlin Academy* for 1740, Maupertuis published a paper on the laws of motion, which was violently attacked by M. Koenig, professor of philosophy at Franeker, who at the same time attributed it to Leibnitz. Maupertuis could not brook the gross imputation of plagiarism which was thus rashly thrown out against him. He persuaded the academy to call upon Koenig for proofs of his charge; and having failed in producing them, his name was expunged from the list of academicians. Several pamphlets were published in consequence of this measure; and, from some cause with which we are not acquainted, Voltaire took a part against the president. Maupertuis threatened to take personal vengeance upon the irritable poet, whom it rendered only more irritated, and who replied to this threat by new assaults of satirical invective.

The severe climate of the arctic regions had produced an effect upon the health of Maupertuis from which he had never entirely recovered. He was attacked with a spitting of blood, and in the expectation of deriving advantage from breathing his native air, he paid several visits to St. Malo during the latter years of his life. During the last of these journeys, in 1757, he was suddenly compelled to quit his native town, in consequence of the arrival of the English in the neighbourhood. From St. Malo he went to Bourdeaux, with the hopes of obtaining a neutral vessel that would carry him to Hamburgh, on his way to Berlin; but having been disappointed in his expectations, he went to Thoulouse, where he remained seven months. He now proposed to try the effects of an Italian climate, but in consequence of his disease increasing, he resolved to go to Germany; and having taken the road of Neuchatel, he had the pleasure of spending three months near Lord Marischal, with whom he had formerly been intimately acquainted. On the 16th October, 1758, he arrived at Basle, where he was most affectionately welcomed by Bernoulli and his family, who watched over him with the utmost tenderness. As the severity of winter came on, the symptoms of his disease became more alarming; and after languishing several months, during which he was attended by his friend M. de la Condamine, he expired on the 27th July 1759. A superb mausoleum was erected to his memory, in the church of St. Roche, at Paris, by M. de la Condamine.

The works of Maupertuis were collected during his life, and published in 4 vols. 8vo. at Lyons, in 1756; and a new and more elegant edition appeared in 1768.

Between the years 1724 and 1749, he published *thirty-five* papers in the Memoirs of the French Academy of Sciences, the substance of which is contained in his collected works. His papers in the Memoirs of the Berlin Academy, between 1746 and 1756, are also numerous. See his *Eloge* in the Memoirs of the Academy for 1759, Hist. p. 259.

MAURA, St. See Ionian Islands.

MAURICE, St. the *Agaunum* of the Romans, is a town of Switzerland in the Lower Vallais. It is situated on the left bank of the Rhone, between the Dent de Midi and the Dent de Morcle, which form part of the two lofty ridges of mountains which flank this river in its approach to the Lake of Geneva. The town consists principally of a long street and a small square, containing some good houses. The chief objects of interest here are the library of the abbey, which contains some Roman inscriptions, and the fine Roman bridge. In leaving the town by the road towards Bex, the road resembles a cornice cut out of a rock several hundred feet high, with the Rhone flowing at a considerable depth below. Huge rocks, interspersed with trees, hang over this road in the most fearful manner; and it is defended on the side of the river by a parapet wall, with numerous embrasures. This path continues for some distance, and is the only road by which a carriage can enter the Vallais. At the end of it we come to a castle, with a large gate, through which there are two passages—one to Geneva by Evian, and the other across the Rhone by an ancient Roman bridge of one arch 130 feet span. The view from the guard-house (about 100 yards on the other side,) back upon the bridge and the castle, with the lofty rocks towering above it, is singularly fine. Beside the stone bridge, the only remains of Roman antiquity are a few sepulchral inscriptions, and two defaced columns. Before approaching the town from Martigny, the traveller will observe a hermitage, on his left hand, perched at a great elevation on the very face of a lofty vertical wall of rock. The ancient town of *Epaunum*, where a council was held in 517, is situated at a little distance from St. Maurice. It was buried, in 562, under the ruins of a mountain. East Long. 6° 52′; North Lat. 46° 15′.

MAURITIUS, or the **Isle of France**, lies in 20° 15′ South Lat. and 57° 29′ East Long. about 100 miles north-west from the Isle of Bourbon. It was discovered by the Portuguese in 1528, and was by them named Cerne or Swan Island, because a number of these birds were seen upon their landing. It was first occupied as a settlement by the Dutch in 1708, and was called by them Mauritius; but they abandoned it entirely in 1712, on account, it is said, of its being overrun with locusts and rats, though more probably because they considered the Cape of Good Hope as a more favourable situation for a colony than an island of such limited extent. The French, who had, in 1664, made a settlement on the Isle of Bourbon, chiefly as an appendage to their establishments on Madagascar, immediately took possession of the Mauritius upon the departure of the Dutch; but it was not till the year 1723 that the island was formally provided with a governor and council. In 1734, the French East India Company, having resolved to form more extensive establishments in the Isle of France, entrusted the direction of the colony to Mahé de la Bourdonnais, who laid the foundation of all its future improvements. In 1766, another eminent superintendant, M. Poivre, rendered great services to the island. He directed the attention of the colonists to the arts of agriculture, and to the raising of grain; and it is to his exertions that the inhabitants owe the introduction of the bread-fruit tree, of the nutmeg and cinnamon tree, and of a superior species of rice from Cochin-China. In the month of November, 1810, it was taken by a British force, under General Abercrombie, after a short and slight resistance, although the attack had long been expected, and every preparation made for the defence of the island. Above 200 pieces of ordinance were found mounted in its ports and batteries. The possession of the place is of importance to Great Britain, chiefly because the French privateers are thereby deprived of a most advantageous station for annoying the East India Trade.

The Isle of France has obviously been the scene of violent convulsions of nature, and is considered as having probably owed its existence to volcanic operations. It abounds in caverns, precipices, subterranean arches, calcined stones, pyrites, vitrifications, and other results of volcanic agency. Some have conjectured that it must formerly have been united with the Isle of Bourbon; and several circumstances have been observed which favour the supposition of the two islands being still connected by subterraneous communications.

The island is of an irregular oval figure, about 14 leagues at its greatest length from north-east to south-west—a little more than 10 leagues at its greatest breadth from east to west; and, following the various windings of the coast, about 18 leagues in circumference. There are numerous capes and bays along the shore, and many dangerous reefs at various distances from the land. The island is divided into eleven districts, which are named Poudre d'Or, Pamplemouses, Flac, Riviere des Remparts, Trois Islots, Grand Port, Savane, Quartier Militaire, Moca, Plaines de Willems, and Plaines St. Pierre. The district of Poudre d'Or in the northern part of the island, is a level plain, formed of shells and other marine productions, and apparently left dry by the retiring of the ocean. The district of Pamplemouses, adjoining to the last-mentioned, is of a similar description; and, in their arid plains, are chiefly produced sugar and indigo, excepting a few marshy spots on which rice is cultivated. In this quarter a considerable tract was reserved by the government, part of which is occupied by a public garden, or orchard, stored with the rarest trees of India and other warm climates. Most of the other districts have a soil of a volcanic nature, and some of them are still covered with the ancient forests. Those of Grand Port and Flac were the first occupied by the Dutch. Moca, a fine plain, well cultivated, and covered with vegetation, and situated to the south of the mountains of Pouce and the Plaines de Willems, separated from the last mentioned by Grand Riviere, and stretching towards the centre of the island, are more recently cleared. Quartiere Militaire is only begun to be occupied, and its distance from the city, and want of good roads, are likely to retard its cultivation. Trois Islots, around the central mountain, is altogether wet and marshy. It may be said, in general, that the south-east part of the island is mountainous, the north-east tolerably level, and the central full of small lakes and marshes.

There are two ports in the island, Port Bourbon, on the south-east coast, and Port Louis, (or more recently Port Napoleon,) on the north-west coast. The former possesses the largest and most commodious harbour; but as it lies to the windward, it is not so favourable for vessels taking their departure. The latter was preferred by Bourdonnais, as, on account of its situation to the leeward, it was more difficult to be reached by an attacking force, and more favourable for the trading ships getting out to sea. Great labour, however, was necessary to keep the channel from being choked up by the gravel, which was washed down by the torrents from the adjoining mountains, and to deepen the entrance of the inner harbour, called Trou Fanfaron, which is a fine bason, 300 fathoms in length, 60 in breadth, and perfectly sheltered from the most violent winds. The principal, and indeed the only, town on the island, is that of Port Louis, situated at the bottom of the harbour, and at the opening of a valley, which is shut in on the land side by lofty and rugged declivities. Upon landing at the quay, the first object which arrests the attention is the Government-House, which is a large and elegant building, constructed partly of stone, and partly of wood, after the Indian mode of architecture, with galleries or balconies running through the whole extent along each story. The police-office and court of justice are also built of stone, but in other respects have little to distinguish them from the other houses, which are constructed of wood, and have, in general, a very mean appearance. The streets are narrow and dirty; and the best houses are to be found in the suburbs, with small gardens attached to them. Such was Port Louis, as described by those who had visited it previous to the year 1816, when a destructive fire laid waste about 19 streets, and reduced about 20,000 individuals to a state of beggary. Among the public buildings destroyed by this calamitous event was the Catholic church; the barracks for the blacks; the grand magazine; the colonial marine storehouse; the public bazaar; the commercial exchange; the government printing-office and post-office; the police and military prisons; the quarter-master general's office and storehouse; the great cooperage, timber and mast yard, weighing yard, and several guard-houses. Fifteen hundred houses were burnt, and the loss of property was estimated at eight millions of dollars. By a proclamation of the governor, the wisest precautions have been adopted to prevent the recurrence of a similar catastrophe; and about 11,000 toises are to be added to extend the town, which formerly occupied altogether about 40,000 square toises. Rue Royale is to be opened to the width of 50 feet, and the other streets to 42, 40, 36, &c. The kitchens are directed to be built of stone, and covered with flat roofs instead of shingles of wood. The fire places are also enjoined to be made of masonry, and the chimneys to be raised to a proper height. The Champ de Mars is a large square, formed by the adjoining hills, at the foot of which are many elegant cottages; and at the upper part of the space is a superb monument, begun in honour of a former governor, but left unfinished from want of funds. In this square the inhabitants meet in fine weather, for the purpose of walking, reading, hearing military music, and often remain to a late hour in the evening. All people of colour, though free, are excluded from the town, and reside in a suburb called Blacktown.

The climate of Mauritius, in the central parts of the island, is more pleasant and salubrious than on the coast, where the heat from November to April is almost insupportable. During this season, the inhabitants of Port Louis can go out of doors only early in the morning, or late in the evening; and all who are not obliged by their employments to remain in the town, betake themselves to the higher and windward parts of the island. In the elevated and inland district, the mean height of the thermometer in July, 1805, (the middle of the winter season,) was 67½°, and in February following (the middle of summer) 76°; but at Port Louis it stands from 7° to 12° higher at an average throughout the year. There is this farther difference between the climate of the coast and the interior, that June, July, and August, the driest months at Port Louis, are the most rainy in the central parts. During the months of January, February, and March, the most destructive hurricanes usually prevail, though, of late years, they have been less frequent, in consequence, as it is conjectured, of the clearing away of the woods, and the greater dryness of the atmosphere. These hurricanes commonly continue for the space of 18 hours, and the wind, in that time, usually makes the whole tour of the compass. They are accompanied with torrents of rain, and often occasion incalculable damage to the houses, plantations, and shipping. In 1773, during the prevalence of one of these storms, the church, and more than 300 houses, were destroyed in Port Louis; and on the windward side of the island, the sea rose 45 feet, covering the fields with fish. On the 28th of February, and the 1st of March, 1817, two very destructive hurricanes were experienced, which did immense damage to the plantations and shipping, and occasioned the loss of many lives. All the vessels in the harbour, to the number of 50, were either lost or damaged, to the extent of 350,000 dollars. The blast was most violent from the north-east; and many persons observed that the rain water had a salt taste. The thermometer was lower than ever it had been observed; and the barometer, which stood at 28° on Feb. 28, at seven A. M. sunk to 26° by six in the evening, and to 20° by five o'clock on the following morning.

The land rises gradually from the coast to the centre of the island, but none of the mountains are more than 2700 feet above the level of the sea. In the middle of the island there is an elevated district, called Vacouas, or Vacois, from the number of pandanus trees, called Vacouas, which grow on the borders of a lake in the centre of the tract. The height of this plain above the level of the sea is nearly 1270 English feet; though the ascent from Port Louis is extremely gradual, the declivity on the west towards the sea (from which it is only six miles distant on that side) is so rapid, that it has there all the appearance of a mountain. In the middle of this table land is a conical pointed mountain, in the form of a sugar loaf, and which is called Piton du Milieu. The other mountains of the island, separated from each other, seem to form isolated groups, which slope gently towards the sea; but on the side towards the interior, present pretty steep declivities. These groups are called the mountains of Faience, of Grand Port, of Savane, of Riviere Noire, of Rempart, of Garde du Corp, and of Pouce. It is from the last mentioned that the most complete view of the island may be attained, as the other more elevated points are neither so accessible nor so favourably situated for a survey of the whole country. The island presents numerous appearances of a volcanic origin; and it has been conjectured that the principal crater must have been in the centre, the dome of which having fallen in, the Piton was thrown up by the last exertion of the subterraneous agent. Around this central mountain are extensive lakes and marshes, from which the principal rivers of the island take their origin.

Two rivers, called the Tamarin and Rempart, which collect the smaller streams around the lake Vacouas, and run parallel to each other, at nearly half a mile's distance, enter the head of the Baye du Tamarin. In the rainy season, they flow in torrents, the former presenting a variety of romantic cascades, and the latter frequently overflowing the plantations on its banks. The river Tombeau, after receiving that of Calebasses, flows through the northern plains; and that of Lataniers waters the valley of Anse des Pretres, in the district of Plaines de Willems.

The lake called Mare aux Vacoues, one of the natural curiosities of the island, situated in the higher part of the interior Table Land, is above one mile in length, and in some places 20 or 25 fathoms deep. It is surrounded with many hundred acres of swampy ground, through which four or five little streams flow into it from the hills behind; and it is well stocked with eels, prawns, and a small red fish called damecerė, originally brought from China. The eels and prawns, which are indigenous, reach to a great size; and some of the former have been offered for sale, which were more than twenty feet in length, and 80 lbs. in weight. Another fresh water lake, called the Grand Bassin, a little more to the south, is still more elevated than the last mentioned; and except the very ridges and tops of the mountains, is in the highest part of the island. It is nearly half a mile in diameter, circular in its form, of great depth, and surrounded with steep rocky banks. No perceptible stream runs into it, but several flow out through hollow parts of the rocky bank, and form the sources of so many rivers. About a league eastward is a lake called the Mare aux Joncs.

The prevailing soil of Mauritius is argillaceous, and of a reddish colour. In many places, it has a volcanic appearance, and is full of stones. The island, when first discovered, consisted of one vast forest, the trees growing to the very summits of the mountains; and still a third part of the surface is covered with the primitive woods. These, in many parts of the interior, are so exceedingly thick, and interwoven with different kinds of climbing plants, that it is scarcely possible to penetrate them.

The original grants of land were usually about 160 English acres in extent, which was called *un terrein d'habitation*, or, more concisely, a habitation, though no house should be built or tree cut down; and the term is now applied to any farm or plantation, of whatever extent. A plantation is divided into its different portions, by a double row of trees or shrubs, with a path running between the lines. For this purpose are used the *vacoua pandanus*, which forms a good fence with its long fibrous and prickly leaves; the rose apple, which yields more shade, and is particularly useful for sheltering the coffee trees; the banana, of which there are various kinds; the pine apple and peach; the China rose, and a bushy shrub from India, called netshouly, which thrives in every soil; and sometimes a strong tall grass, called vitti-vert, which may be cut twice or thrice in the year, as materials for thatching, is preferred for the lines of division; while the waving bamboo is planted along the canals and rivers.

Cleared lands, which have ceased to be cultivated, are soon covered with a strong coarse grass, named chien-dent, intermixed with ferns, wild tobacco, and other noxious weeds; but, in the low districts, during three or four months, and in marshy places during the greater part of the year, grass of a better kind is produced, which supplies the cattle with tolerable food. At other times they are fed with maize straw, leaves, and tender branches of certain trees, and the refuse of the sugar mills. A principal part of the land is planted with the manioc bread-tree, (introduced from Madagascar by M. Poivre, in 1766,) with maize, and sweet potatoes, as these articles form the chief sustenance of the slave population; and two crops are procured in one year, the first of wheat and the other of maize. Vegetables and fruits, for the supply of the market, are raised in considerable quantities, within a certain distance of Port Louis; but the sugar cane, cotton shrub, coffee plant, clove tree, indigo, and tobacco, are the most general objects of culture. It is estimated that a plantation should yield a profit of 20 per cent. on the capital employed on it, after making a fair allowance for ordinary losses.

The native timber is of excellent quality, and in considerable variety, such as iron-wood, black ebony, stinkwood, colophonium-wood, pine-tree, European oak, besides the black and white cinnamon, cabbage-tree, olive-tree, and apple-tree, which are all indigenous. The tamarind, acacia, nutmeg, and clove trees, have been introduced, and thrive well, and a quantity of spices is raised, sufficient for home consumption. The indigenous fruits are of little value, and are chiefly the fruit of the black ebony, of the palmiste or cabbage-tree, citrons and rasberries; but guavas, bananas, peaches, pine-apples, mulberries, and strawberries, are raised in most of the plantations, and, in those which are deserted, continue to grow wild till the arrival of a new occupant. Most of the plants and shrubs of tropical climates are produced on the island in abundance: the ginger-root in every quarter; and aromatic plants are so numerous, that their odour may be felt at sea in the direction of the prevailing winds.

By an act of the British parliament in 1817, the ports of Mauritius are opened to the vessels of all nations for three years, with certain exceptions in favour of British manufactures and British ships.

The following Table may furnish some idea of the principal articles of commerce in the island.

IMPORTS.	EXPORTS.
Rice, (fine moongee,)	Java coffee,
Sugar, (fine Benares,)	Java sugar,
Grain,	Bourbon coffee,
Soap, (Bengal,)	Colonial sugar, (1st sort,)
Twine, three threads,	Ditto, (2d sort,)
Wax candles,	Ditto, (3d sort,)
Wheat,	Pepper,
Gunny bags,	Cloves,
Cocoa nut oil,	Ebony.
Piece goods, (if well assorted,)	
Hog's lard,	
Canvas, (hemp,)	
Ditto, (hemp and cotton,)	
Chairs, (neat and solid,)	
Salt provisions,	
Coil rope,	
Indigo.	

The animals of Mauritius are by no means numerous. Cattle are very abundant in the mountainous districts, particularly goats. The Indian buffaloe has been introduced, and its breed greatly improved; and these animals are found to be more suited to the more elevated and humid tracts than the common bullock. A bounty was offered in 1817, for the importation of mules and asses from Asia, as a substitute for the manual labour of the Negroes. Deer and wild hogs are found in the more remote woods; and a few short-legged hares in the vicinity of the plantations. Apes are very abundant in the higher grounds, and are frequently used as food by the Negroes. Tandrecs are also very common in the forests, and become very fat and sluggish. There are great numbers of rats, which prove extremely destructive to the plantations.

The birds of this island are not numerous, and are mostly of the smaller tribes. There are some singular birds of prey, particularly of the eagle species. There are partridges, wood-pigeons, and doves. In the marshy spots are a kind of water hens, but no wild geese or ducks; and game in general has become very scarce since the period of the French revolution, which left the Creoles more at liberty to follow the sports of the field. Parrots are remarkably plentiful in the higher forests. There are two beautiful kinds of loxia, the cinericious and red-coloured; the latter of which, called cardinal, about the size of a sparrow, is of a bright fiery hue, and appears among the leaves like a scarlet flower. Both these birds are very destructive to the grain crops, especially to the rice fields; but another bird, the martin, was brought from the Philippines, for the purpose of checking the growth of the insect tribes, which it has completely effected. There is still, however, a considerable variety of beautiful insects on the island, butterflies, caterpillars, moths, grasshoppers, wasps in great numbers, and wild bees, which produce a good deal of honey. Bugs, fleas, cockroaches, spiders, sand flies, centipedes, and musketoes, infest the lower districts, but are less frequent in the higher and western regions of the island. A most destructive moth, called kakerla, or kancrelat, (*Blatta Americana ferruginea*,) is one of the greatest pests of the island, and attacks every kind of substance, leather, shoes, boots, the binding of books, paper, candles, provisions. Its great enemy is a beautiful green fly, (*Sphex lobata*,) which is perpetually in motion, and which buzzes around the moth till it becomes stupified by the unceasing motion, and, having stung it to death, drags it to a hole, covers it with eggs, shuts up the opening of the recess with a kind of cement, and leaves the dead insect as food to the future progeny of its conqueror. Ants are extremely numerous, and infest every place, the roads, walls, trees, houses, and streets. One kind particularly, named karia, a species of thermites, occasions great damage to the finest trees and all sorts of timber work. There are no serpents on the island, nor any venemous insects, except some kinds of scolopendra, and a small species of scorpion, which are very common every where. By the care of the Marquis of Hastings, and of governor Farquhar, silk worms have been introduced into the island, and promise to make an important accession to the prosperity of the colony.

The fish on the coast are very abundant and excellent; among which are found the *Ostracion quadricornis*, and the *Tetraodon testudinarius*, the latter of which, called the purse, raises itself to the surface of the water, by inflating the skin of its belly so as to become quite round. It is then unable to direct its motions, and requires some time to reduce its inflation. There is a great variety of crabs, molluscas, and sea-stars.

There are no villages in the island, and only one town, which is the seat of government, and the resort of trade for the whole island. About half a dozen houses may sometimes be found together in the country; but the plantations are scattered irregularly over the surface, and families within a mile of each other, are considered as very near neighbours. The population, which in 1810, is said to have been only 20,000, is considered as now about 80,000. The proportion of slaves, who are chiefly from Mozambique and Madagascar, is to the whites and free people of colour as ten to one. Those from the last mentioned place are accounted most valuable, on account of their bodily activity, their quickness in learning the language, and their ingenuity in acquiring handicraft trades; but those from the former country are chiefly used on the plantations, and at the ports, as beasts of burden. In the town, the merchandise is dragged to the warehouses in large waggons or drays, by 12 or 14 Negroes attached to each; and not less than 500 are supposed to be daily employed at Port Louis in this degrading toil. In the same manner, the greater part of the agricultural produce is transported on men's heads and shoulders to the principal port; and even the female slaves are sometimes driven along under these loads.

The middling classes, in Port Louis, are generally very industrious, and excel as mechanics. All the useful trades are carried on in the place with much spirit and success. Their iron founderies and articles of hardware are said to equal almost those of Birmingham; and ship-building is conducted to a considerable extent, and with many local advantages. The higher ranks of settlers are said to be extremely hospitable and kind to strangers; but in general very lax in their morals, and often openly licentious. There are a few intelligent men, who maintain an excellent library, which is open for the use of the public; and a society of emulation was instituted in 1805, for literary and philosophical pursuits, but principally for promoting the interests of agriculture, navigation, and commerce. See Flinders' *Voyage*, vol. ii.; Grant's *Account of Mauritius*; *Voyage dans les quatre principales Isles des Mers Afriques*; par J. B. C. M. Bory de St. Vincent. (*g*)

MAUROLYCUS. See OPTICS, *History of*.

MAXIMA and MINIMA. See FLUXIONS.

MAYEN JAN'S ISLAND, is an island in the Greenland Sea, to the south-west of Spitzbergen. It is situated between north latitude 70° 49′, and 71° 8′ 20″; and between West longitude 7° 25′ 48″, and 8° 44′; and received its name from that of its discoverer, who visited this island, according to the Dutch authorities, in 1611. It stretches from north-east to south-west. Its north end rises into a mountain called Beerenberg, from its being haunted by bears, which raises its icy summit to the height of 6870 feet above the level of the sea. The general appearance of the land has a striking resemblance to the coast of Spitzbergen, both in colour and character. Between the capes, north-east and south-east, there are three remarkable icebergs, which Captain Scoresby ascertained geometrically, to be about 1284 feet in perpendicular height. "Seeing," says Captain Scoresby, "a steep and peculiar looking mount close by, from which the profusion of cinders, earth-slag, burnt clay, scoriæ, &c. around us, seemed to have been projected, we hastened to climb its loose and rugged sides. The steepness of the hill, and the looseness of the materials of which its surface was composed, made this ascent a most fatiguing undertaking. We sometimes slid backwards several paces, by reason of the nodules of lava rolling away from under our feet. We met with no minerals in our progress but those of the class of lavas, which, in many places, rung beneath our steps, like a number of empty metallic vessels.

"About the base of the volcanic mount, we met with vast blocks of a ponderous rock, of a bluish-black colour, containing numerous green-coloured crystalline or vitreous substances: about the middle, scoriæ, cinders, and earth-slag, having altogether a brownish-black appearance, together with large lumps of burnt clay, lay in great abundance; towards the top, masses of half-baked red clay, of a friable texture, containing semi-vitrified and crystallized substances, occurred; and at the summit, prodigious blocks of the same, ranged along the southern margin, gave the mountain a castellated form of no small magnificence. Beyond these rocks of red clay on the top of the mountain, we beheld the crater, forming a basin of five or six hundred feet in depth, and six or seven hundred yards in diameter. It seemed perfectly circular at the top, and sloped on the sides with a similar steepness as the exterior of the mountain, so that the descent was by no means difficult or hazardous. The bottom of the crater was filled with alluvial depositions to such a height, that it presented a horizontal flat, of an elliptical form, measuring about 400 feet by 240. A subterranean cavern was here seen penetrating the side of the crater, from which issued a spring of water, which, after running a short distance towards the south, disappeared in the sand. The summit of this volcanic mountain, which was 1000 to 1500 feet in elevation, afforded a view interesting and grand. To the north appeared Beerenberg, now first distinctly seen free from clouds, rising in majestic importance by a steep and increasing slope from the very verge of the sea on the south, to the height, apparently, of the highest clouds. At the foot of the mount on the south-eastern side, near a stupendous accumulation of lava, bearing the castellated form, was another basin, or crater, of a volcano, of smaller dimensions, situated on a level very little above that of the sea."

In the winter of 1633, seven sailors were left on Jan Mayen's Island, but they were all found dead on the 7th of June following by some Dutch, who arrived on the island. They had lived through the winter, as their journal was brought down to the 30th of April. See Forster's *Hist. Voyage to the North*, p. 422; Laing's *Account of a Voyage to Spitzbergen*, in 1806, p. 57; but particularly the *Edinburgh Philosophical Journal*, No. I. p. 121, where Mr. Scoresby has published an account of his visit to this island.

MAYENNE, the name of one of the departments in the north-west region of France, which was formed out of the Lower Maine, and receives its name from the principal river by which it is watered. It is bounded on the north by the departments of La Manche and the Orne; on the west by that of the Ille and Vilaine; on the south by that of the Maine and Loire; and on the east by that of the Sarthe. It is about 22 French leagues in length, and 16 in breadth, and has an area of 266 square leagues. The soil in the department is of unequal quality, and is fertile. The cantons which yield most wheat are those near the rivers Loire and Mayenne. In some places the land lies four or five years in fallow. The chief productions of the department are corn, wines, hemp, beef, fruits, silk, honey, brandy, and sweet oil. It carries on some trade in these articles, and in timber. The manufacture of linen cloths is carried on principally at Laval and Mayenne. Those of Laval have the highest reputation. There are very fine bleachfields in the district of Chateau-Gontier. In the neighbourhood of Laval there are fine quarries of jasper and marble. The principal towns are, Laval, the capital, population 14,154; Mayenne, population 7575; Chateau-Gontier, population 4656. The forests occupy about 50 or 51 thousand acres. The contributions, in the year 1803, were 3,111.618 francs, and the population 328,397.

MAYENNE AND LOIRE. See MAINE and LOIRE.

MAYER, JOHN TOBIAS, a very eminent German mathematician and astronomer, was born at Marbach, a small town in the duchy of Wirtemberg, on the 17th of February, 1723. He did not enjoy the advantage of a regular academical education; but his genius and application enabled him, at an early age, and without any assistance, to become a proficient in the mathematical and mechanical sciences, which he afterwards cultivated with such success as rendered his name celebrated throughout Europe. Some essays which he published in his twenty-second year attracted attention, and probably were the means of his procuring an appointment, in 1746, in the geographical establishment originally instituted by Homann at Nuremberg, where his talents were usefully employed in preparing the maps which were published by that company. His *Critical Map of Germany*, in which he corrected a multitude of errors, was particularly esteemed. He was, at the same time, admitted a member of the cosmographical society of Nuremberg, and contributed several memoirs to the collection published by that body, which may be considered as the precursors of his larger works on the theory of the lunar motions, and the determination of the longitude.

The highly interesting train of investigation, however, in which the genius of Mayer was now engaged, would probably never have been prosecuted to a successful issue, had he not been placed in a situation more favourable to the cultivation of science, by his appointment to the professorship of mathematics in the University of Göttingen, in the year 1751. He availed himself, with indefatigable zeal and industry, of the advantages which he now enjoyed; and he was still farther stimulated to the prosecution of his astronomical labours, when, in 1754, the principal charge of the observatory was committed to him. His unremitted exertions, however, seem to have exhausted his frame; and his death is also supposed to have been hastened by the sufferings to which the town of Göttingen was exposed during the seven-years' war. He died on the 20th of February, 1762, at the age of 39.

The services of Mayer have long been justly appreciated by men of science. His reputation is chiefly founded on his *Lunar Tables*, which he calculated with a degree of exactness till then unknown, and which he continued to improve until the day of his death. He adopted the theory of Euler, after having carefully investigated the correctness of its principles, and compared them with the results of his own accurate observations. About this period the attention of men of science in England had been directed to the discovery of some means of determining the longitude at sea, for which a considerable reward had been offered during the reign of Queen Anne. As Mayer's lunar tables seemed to afford the means of attaining this object, he was encouraged to lay claim to the reward, and accordingly transmitted a copy of his tables to the Lords of the Admiralty in 1755. He did not live, however, to reap the reward of his services; but the accuracy and utility of his labours were acknowledged, and his widow received 3000*l*. being a part of the sum which had been offered for the discovery of the longitude.

The principles upon which Mayer proceeded in constructing these tables are developed in the two following works: *Theoria Lunæ juxta Systema Newtonianum*, London, 1767, 4to. and *Tabulæ motuum Solis et Lunæ*, ibid. 1770, 4to. These tables, however, had been previously published in the *Memoirs of the Royal Society of Gottingen* during the author's lifetime, and were afterwards several times reprinted with improvements.

Mayer also delineated with great neatness and accuracy, a new map of the moon's disc; and he made some important observations on the peculiar motions of the fixed stars, besides constructing an improved catalogue of 992 of these bodies. His manuscripts, which, in addition to the matters already mentioned, contained some treatises on physical subjects, were purchased by the government for the university of Göttingen, and preserved in the observatory. Lichtenberg began to collect and to publish Mayer's unprinted treatises, but of this work only one volume appeared, *Opera inedita*, vol. i. Göttingen, 1774, fol. (*z*)

MAY, ISLE OF. See FORTH.

MAYNOOTH, in the barony of Salt, county of Kildare, and province of Leinster, in Ireland, about 11½ miles west by north from Dublin, is remarkable only on account of the royal college of St. Patrick, which was established here in the year 1795 by act of Parliament, for the education of persons professing the Roman Catholic religion; and to a short account of this college this article will be confined.

Before the establishment of this seminary, the Irish youths, who were intended for the Catholic ministry, in general received the rudiments of their education in hedge-schools. When they quitted these, some of them received deacons' orders from the Catholic bishops; and then having obtained, generally by charity, a small sum of money, they proceeded to the Irish colleges on the continent, where they maintained themselves by saying mass. Others received priests' orders before they went abroad; and thus being enabled to exercise a greater number of ministerial functions, were better able to support themselves. A few went abroad before they received either deacons' or priests' orders. They remained at the foreign seminaries for three years, or longer, if they had not previously received deacons' orders, and then returned to seek a living in Ireland.

The following were the establishments for Irish Catholic secular clergymen on the Continent before the Revolution:

	Mast.	*Schol.*
In Paris, College de Lombards,	4	100
——— Community, Rue Cheval Fort	3	80
Nantz,	3	80
Bourdeaux,	3	40
Douay,	2	30
Toulouse,	1	10
Lisle,	1	8
Total in France,	17	348
Louvain,	2	40
Antwerp,	2	30
Salamanca,	2	32
Rome,	2	16
Lisbon,	2	12
Total on Continent,	27	478

The scholars generally went to the public schools and universities; on this account so few masters were necessary. All of them who were in the college of the Lombards, at Nantz, Douay, and Antwerp, and twenty of those who were at Bordeaux, had received priests' orders before they went abroad; and by the exercise of their functions, they were enabled to support themselves during their studies. In the community at Paris, there were foundations for sixty scholars granted by different persons; in Toulouse for twelve; in Bourdeaux for twenty, by pensions from the king of France; in Salamanca for thirty-two, by the king of Spain; in Rome for sixteen; in Lisbon for twelve; and in Louvain for twenty. Of the whole, 166 were supported by foundations; 260 by the exercise of their functions as deacons or priests; and 426 received gratuitous support.

In consequence of the revolutionary war with France, which was soon followed by a war with Spain, the Irish Catholics were unable to send abroad a sufficient number of young men to be educated for the priesthood. This difficulty, however, was removed by a repeal of the greater part of the penal code against them, which induced them to apply to Parliament for the establishment of a Catholic seminary in Ireland. Accordingly, in the year 1793, they petitioned the legislature to obtain permission to establish a university for students of their own persuasion, under a charter of incorporation, in order that the funds raised to support it might be legally secured. In this petition it was explicitly stated, that Protestants, if they thought proper, might send their children to the proposed college. Parliament, however, did not think proper to grant this part of the petition; but in every other respect they acceded to the wish of the Catholics, and voted money for the purpose of assisting them in the erection of the establishment, the site of which was fixed at Maynooth. By the Act of Parliament it is placed entirely under the inspection of the Lord Chancellor and the Chief Judges of Ireland: it was opened in the year 1795; till the year 1800 there were only 50 students; in that year they were increased to 100; and in 1802 there were 200; at present there are about 250. The building originally consisted of lodging rooms, schools, a church, library, hall, and different offices, sufficient for the accommodation of 200 ecclesiastical students, besides the president, &c.; this building cost about 20,000*l.*; afterwards, one of the wings was extended so as to accommodate about 200 additional students: this addition, and some alterations, &c. cost about 10,000*l.* During the infancy of this establishment Parliament voted annually 6000*l.*; this sum was afterwards increased to 13,000*l.*; then for a short time reduced; at present the expense of maintaining the establishment is about 12,000*l.*; the greater part of this sum is defrayed by government; part of it is derived, however, from legacies, donations, &c. and part from the entrance-money of the scholars. From the first of these sources there had been received, up to the year 1808, 3012*l.*; and from the other source, 5635*l.*

The officers and professors consist of a president-general, governor of the college; a vice-president-general, governor in the absence of the president; a dean; a procurator, or bursor; a professor of dogmatic theology; a professor of moral theology; and professors of natural and experimental philosophy; of logic; of belles lettres; and of Greek and Latin; besides lecturers on dogmatic theology; on moral theology, and on logic; a professor of English elocution; a professor of the Irish language; a treasurer and secretary to the trustees; a physician, and an agent.

No person can be admitted as a student till he deliver to the president a certificate of his age, parentage, baptism, and of his having taken the oath of allegiance: he must also be recommended by the Catholic prelate in whose diocese he lives, and pass an examination in the Classics to the satisfaction of the major part of the examiners. The students are accommodated with lodgings, food, and instruction. Coals and candles are also supplied them in the public halls, during the hours of study. Each student pays 9*l.* 2*s.* as entrance money, and provides himself with clothes, books, bedding, and chamber furniture, besides paying for washing, mending, and candles and coals for his room. The whole of these expenses may amount to about 20*l.* per annum. The course of study embraces humanity, or the under class of Greek and Latin; belles lettres, or the first class of Greek and Latin; logic, metaphysics, and ethics; elementary mathematics, algebra, geometry, conic sections, astronomy, mechanics, optics, hydraulics, &c.; chemistry; divinity; moral theology; and the English, Irish, and French languages. The general order of each day is as follows:—5 in the morning, the first bell rings; 5½, common prayer; 6, study in the public halls; 7½, mass; 8, breakfast; 9, study in the public halls; 10, class; 11½, recreation; 12, study in the public halls;—in the afternoon, 1½, class; 3, dinner; 5, class for the modern languages; 6, study in the public halls; 8, supper; and, at half after 9, all retire in silence to their chambers. Every Sunday and holiday a sermon or homily is read by one of the students in holy orders: Wednesday is devoted to walking or recreation. Both deacons' and priests' orders are conferred at Maynooth. In the year 1802, a lay college was established at Maynooth, by private subscription. See Carlisle's *Topographical Description of Ireland*;—*Papers presented to the House of Commons, relating to the College at Maynooth, in* 1808 *and* 1812;—and Wakefield's *Account of Ireland.* (W. S.)

MAYO, a maritime county of Ireland, in the province of Connaught, is bounded on the west by the county of Sligo and the Atlantic ocean, on the north by the Ocean, on the east and north-east by the county of Roscommon, and on the south by the county of Galway. It is about 54 miles in length, and 48 in breadth: its area is computed by Dr. Beaufort, in his Memoir of a Map of Ireland, to contain 1235 Irish square miles, or 790,600 Irish acres: it is divided into 8 baronies, and one half barony, and into 68 parishes. The baronies are, Burrishoole, Cortello, Tyrawley, Gallen, Killmain, Murrisk, Carra, and Clanmorris, with the half barony of Erris. The surface of the greatest part of this country is covered either with mountains or bogs; there are, however, valleys of considerable extent; and the country bordering on the lakes of Mask and Carrah, as well as that part of Erris called the peninsula of Mullet, or within the Mullet, are flat. The rest of Erris is extremely wild, and from November to April almost inaccessible, the few mountain passes being then filled up with marshy swamps. This barony, with those of Tyrawley and Burrishoole, are the most mountainous districts of Mayo. This district is bounded on the north and west by the Atlantic; on the south by Cleir Bay, and a chain of mountains from Newport Prat to Lough Cullen, on the east by the river May, Lough Corin, and Lough Cullen, which separates it from Sligo. There are two mountain chains in this district—one in the centre, and one along the north coast. The smaller hills are covered with bog from 1 to 10 feet deep; the bog in the valleys is 30 feet deep. This mountainous district contains 477,850 English acres, of which 152,260 are cultivated, or covered with sand; the latter is the case in part of Martlett; 155,500 are nearly unproductive mountain, and 170,090 are unproductive bog. In this district is Mount Nephin, one of the loftiest mountains in Ireland: it is 2640 feet above Lough Corin, and 2670 above the sea; it is divided from the rest of the chain by a deep glen; this mountain rises with magnificent regularity from its base, and, in the opinion of Mr. Young, is one of the finest mountains he ever saw. Mayo is also celebrated for another lofty mountain, Croagh Patrick, in the vicinity of Cleir Bay, which, according to Dr. Beaufort, is 2666 feet above the level of the sea. The bogs of Mayo, from their extent, deserve consideration next to the mountains. Mr. Bald surveyed three large districts entirely within the county, and has given a very particular account of them in the report of the Commissioners on the bogs of Ireland, laid before parliament. The first district comprises the bogs near Castlebar, which discharge their waters into Lough Mask, Lough Corin, and Cleir Bay; the second district comprises the bogs in the south-west of the county which discharge their waters into Cleir Bay, Killeny harbour, and Lough Mask; and the third district comprises the bogs in the east of the county, which discharge their waters into the May, Lough Mask, Sligo Bay, and Lough Gara; in part of this district there are remarkable ridges of lime stone gravel: the general elevation of all the districts is about 400 feet above the ocean. There are several Loughs in Mayo, particularly among the mountains: Lough Corin, at the foot of mount Nephin, is 9 miles long; Lough Mask is 2 miles longer and considerably broader, but it lies only partly in this county. There is a subterraneous communication between Lough Mask and Lough Carrah with Lough Corrib; the summer surface of the first above that of the last lake is 36 feet; the subterraneous communication takes place at Cong, where the water springs up in great quantity. This part of Mayo abounds with *turlahs*, or plains, which, though not visibly connected with brooks or rivers, in winter are covered with water: in summer the water retires through rocky cliffs in the bottoms, and the plains afford a rich and firm pasturage. The only river of consequence is the May, which rises in the county of Sligo, and falls into the Atlantic at Killala, with a broad stream. At Ballina it is 200 yards broad: it is navigable for small craft 6 miles from the sea. The coast of Mayo is in general very high, especially on the north; the average height of the headlands here is 400 feet; one of them is 745 feet, nearly perpendicular. The coast is also lined with islands. The principal are Achill Island, the largest on the coast of Ireland, containing 24,000 acres; Clara Isle, containing 2400 acres; and Bophin Isle, containing 1200 acres. There are several excellent bays and harbours, but they are much neglected. Killeny harbour, which separates Galway and Sligo, is one of the best on the west coast of Ireland: it extends inland 7 Irish miles: its greatest breadth is 5 Irish furlongs; its depth of water is sufficient for a first rate man of war. Newport Bay is 4 miles long, and contains several good roads for the largest vessels. Clara Island lies before it, and it contains at least 30 small islets, all cultivated. Blacksod, or Cleir Bay, is formed by Achill Island on the south; the entrance is 4 miles wide, and it affords a land-locked harbour for the largest ships. Proceeding to the north, are the islets called the Stags of Broadhaven, where an interval of clear coast, bounded by steep rocky cliffs, commences. The safest coast is the northern, and the best port in it is Killala, which is entered over a bar with 10 feet water at neap tides.

The natural history of Mayo presents little that is interesting. Croagh Patrick, and the adjacent mountains, are formed of fragments of granite and sandstone. The whole of the mountain chains in the north-west of the county consist of primitive gneiss, mica slate, and granular quartz rock; the secondary rocks overlaying the primary at the base, are, on the south side, red sand-stone, covered by floetz limestone; on the north, red sand-stone covered by slate clay, alternating with floetz sandstone, and floetz limestone alternating with slate clay. The Nephin mountain consists principally of mica slate: massive actinolite occurs in the east side. The limestone that prevails in Mayo is part of the great limestone valley that stretches from Dublin across the island. There is a large slate quarry in the mountains of Clanmore, near Westport; the best sort of slates dug from it are said to be superior in quality to any brought from England. Quarries of excellent freestone, fit for building, are found in this county. Vast quantities of iron ore are found in the Barony of Murrisk; and there were formerly iron-works, but they are given up for want of fuel. Eagles abound, especially near and on Achill Island, which takes its name from that bird; they do great mischief by carrying away lambs, poultry, &c.; they even dart in, and carry off the salmon, when they appear above the water. In the lake of Castlebar, near that town, is the char, and the gillaroo trout, with gizzards; there are no pike in the lakes of this county. The climate of Mayo, though it is exposed to violent winds, and a great deal of rain falls, is uncommonly mild, so much so, that the Marquis of Sligo has flourishing plantations very near the sea, in situations very much exposed to the westerly winds, and very elevated.

Mayo is chiefly possessed by immense landholders; notwithstanding this, however, the number of registered 40s. freeholders is considerably greater than in any other county of Ireland; there being, according to the returns to Parliament, 15,443; and 200 registered freeholds of 20*l*; and 193 of 50*l*. On Lord Dillon's estate, which is one of the largest in the country, there are 2100 registered freeholders. Some of the farms are very large; those near Castlebar, and in some other parts, extending to 3000 acres, but these are stock or grazing farms; the farms around West Port are from 400 to 5000 acres, all stock farms. But the greatest part of the county is let in partnership, or on the village system, especially the small patches of arable land; each village has a code of law for regulating their agriculture; if disputes arise, an appeal is made in the first instance to the agent, and afterwards to the landlord. Where arable land is not held in this manner, it is taken from the store farmer or grazier, by cotters, as they are called, at a very extravagant rent. Thirty pounds for four years is the common rent of an acre thus let. The best lands in Mayo bring 40s.; the worst 20s. an acre. Grazing is the principal object of farming; and the barony of Tyrawley is among the best parts of Mayo for this purpose; there is likewise good grazing ground in some parts of Clanmorris, Kilmain, and Cortello; the grazing grounds of the last are of a remarkable quality for fattening and a return of tallow. There are a few small dairies; the cattle kept for them, and for fattening, are a mixture of the long-horned English breed with the native breed: a great many fine beasts are to be found in this county. Scarcely any sheep are kept, and very few swine, and those of a bad kind.

Arable husbandry is confined to the flat lands of the peninsula of Mullet, to the valleys and the bottoms of the mountains; a great part of the baronies of Burrishoole and Murrisk are in tillage. Arable husbandry, at least so far as oats are concerned, has been much extended, by the establishment of corn buyers, who ship this grain for Scotland; but the arable husbandry, though extended, is still very bad. They plough with four horses, generally directed by a man walking backwards; young colts are fastened to the harrows by the tail; and they often burn their corn, instead of thrashing it. Twelve horses are necessary for 100 acres in tillage. Their implements are constructed on the worst principles, and in the most clumsy and insufficient manner. Barley, oats, potatoes, and flax are grown; formerly much barley was grown in the barony of Cortello, but potatoes and oats are at present chiefly cultivated. On the sea-coast of Tyrawley potatoes and barley are the common rotation; in other parts of the country, potatoes, oats and flax, and then the land is left to recover for some years.

Such of the inhabitants as are not employed in agriculture pick up a scanty and precarious living in fishing, burning sea-weed, or collecting it for manure, and spinning of yarn. At Ballena there is a salmon fishery, one of the most considerable in the kingdom. In the bay of Killala a great number of herrings are taken. but this fishery has nearly declined of late years. Lobsters, turbot, and various other kinds of fish, are plentiful. Herring nets are made at Killala; and at this place and Ballena there is a small market for linens; spinning is universal in all the cabins, and they spin and weave enough to clothe themselves.

The principal towns are Castlebar, Killala, Ballinrobe, Ballena and Newport: Mayo, though now decayed, was formerly a large place, and noted for its university, at which King Alfred was educated: Castlebar is the capital of the county: Killala is a bishop's see; it was established in the fifth century; and in the sixth the see of Achonry was united to it. The united sees measure east and west 55 miles, and from north to south 21 miles, there are 50 parishes in them. Some parts of Mayo are very populous, considering the nature of the surface and soil. Even in the three large bog districts, the population has risen on the sides of the mountains 500 feet above the level of the sea; and descended to the very edge of the bogs, so that there is only about 2½ acres capable of aration to each family, or half an acre to each individual. The number of houses in the whole county is estimated at 27,970; and of inhabitants at 140,000: taking the area at 1235 square miles, this will give 22,64 to a square mile; and supposing the number of acres to be 790,600, there will be 2.82 to each house. Nearly the whole population is Catholic: in the year 1740, there were only 824 Protestant housekeepers; and in 1792, out of a population of 140,000, it was calculated that there were only 1750 Protestants. There are districts of 50 miles where a Protestant church is not to be seen. The county sends two representatives to Parliament. The inhabitants in general are very poor, ignorant, and wretched; their cabins have a most miserable appearance; their food is potatoes, cockles, herring, and a little meal and potatoes; a man, his wife, and three children, will eat a bushel of 3 cwt. every week; and of oatmeal the common allowance is a quart a day for a labourer; they likewise use a deal of butter-milk, and *bonny clobber*; the latter is sour milk, or lappered milk, as it is called in Scotland. The cotters who keep cows fare better; they reckon that the men feed the family with their labour in the field, and the women pay the rent by spinning. Except in the peninsula of Mullett the Irish language is the only one understood or spoken. There are several of the singular buildings, called round towers, in the county of Mayo; and two remarkable square towers at Moyne and Rosserice: it also contains a great many other monastic remains. See Macparlan's *Statistical Account of Mayo;* Wakefield's *Ireland;* Beaufort's *Memoir of a Map of Ireland.*

MAZANDERAUN. See PERSIA.

MAZOLOGY.

Mazology, from the Greek *μαζος*, *a breast*, and *λογος*, *discourse*, is that branch of zoology which treats of the class of mammiferous animals, or of those species which have a heart furnished with two auricles and two ventricles, which have red and warm blood, breathe by means of lungs, suckle their young with milk from their breasts, and are *viviparous*, or produce live young. The term *quadruped*, or *four-footed*, would, obviously, apply to a lizard, a frog or a tortoise, as well as to the higher orders of four-footed beasts. With a view to discriminate the latter, Linné introduced the appropriate term *mammalia*, denoting such animals as are provided with organs for suckling their young; a category which, in strictness of arrangement, would comprise the *cetaceous* tribes, which have been so generally, yet so improperly, confounded with fishes; but we have thought it more convenient to treat them under the separate article Cetology. Thus qualified and restricted, then, our definition of the mammalia refers only to those families of animals which, in *common language*, are called *quadrupeds*. Besides their manifest subserviency to our comforts and our wants, there are other considerations which powerfully recommend them to our notice. Their situation and dispositions, for example, are such as to afford us more frequent opportunities of intercourse with them than with the other classes of animals. Fishes inhabit an element different from our own: birds soar aloft in the air, and, when they rest on the earth, they generally prefer places not easily accessible to man; insects, from their minuteness, are apt to elude our observation; and reptiles shun our society, or repel us by their very aspect. But quadrupeds cannot so easily avoid us: many of them, on the contrary, seek our fellowship. Their manners and circumstances bear a considerable analogy to our own; while their sagacity, and the constancy of their attachments, naturally attract our observation, and conciliate our affectonate regards.

Sketch of the History of Mazology.

From the reasons which we have just stated, and from various others which we might easily enumerate, we may readily infer, that, even in the earlier stages of society, the attention of mankind would be powerfully solicited to the forms, habits, and economy of the mammiferous races of animals. Scientific views of their natural history, however, could originate only in periods which were characterised by some degree of civilization. From the beautiful allusions to the works of creation which abound in the writings of the Jewish prophets and poets, we may conclude, that these holy personages were no indifferent spectators of the animal tribes which surrounded them; and Solomon, who knew all vegetables, did not, we may presume, overlook the aspects and conditions of those animated beings which were so accessible to his observation.

Our ideas of the information which the Greeks and Romans possessed relative to the history of quadrupeds, are very scanty and imperfect; for many of their works have perished; few which professedly treat of the subject in question have come down to our day; and, even of these, the text has been often injured or obscured, by the waste of time, the negligence of transcribers, or the misconceptions of scholiasts and commentators. The want of a regular nomenclature, too, among the ancient writers, often baffles our attempts to identify their vocabulary with those of our modern zoologists.

Although the works of Apuleius have not been transmitted to our times, it remains on record, that he caused animals of all descriptions to be brought to him, that he might have an opportunity of investigating their structure, and that he undertook long journies for the purpose of exploring the recesses of nature.

In so far, however, as they are known to us by their writings, the two most eminent mazologists of antiquity are Aristotle and Pliny; and the two of subordinate consideration are Ælian and Oppian.

When Alexander the Great, on the demise of his father, Philip, engaged in the grand Asiatic expedition, Aristotle, his preceptor, who preferred the luxury of philosophical leisure to the bustle of a camp, returned to Athens, though he failed not to maintain a friendly correspondence with his royal pupil. The latter, on his part, at an enormous expense, employed some thousand persons, in different parts of Europe and Asia, in collecting various animals, and transmitting them to the naturalist. It would be irrelevant to our present object to enter into any analysis of the critical and metaphysical speculations of an author, who has, by some, been revered as the prince and father of philosophy, and branded by others with all that baseness of abuse which envy and detraction delight to propagate. Neither need we dwell on the extraordinary ascendency which his doctrines long maintained in our schools and seminaries of learning. There is strong reason to suspect, that the original order of his writings is disturbed, and that, in their present form, they are not only mutilated, but that they abound in spurious and interpolated passages; for few of them were made public during his life, and much they have undoubtedly suffered from the decay of time, and from the indiscreet zeal of copyists and commentators. To these formidable discouragements under which we peruse the pages of the Stagyrite, we have to add the inherent concision and assumed mysteriousness of style, which veiled from the uninitiated the more recondite portions of his multifarious information. Of the fifty volumes or books, which he composed on the history of animated nature, only nine have been preserved. In these, he lays down certain general points of difference and resemblance observable among various kinds of animals, and then details, historically, the facts and notices connected with general relations and sensible characters. These last he deduces from the form, colour, size, and other external qualities of the whole animal, as well as from the number and position of its parts; the dimensions, movements, and forms of its limbs, with their comparative analogies or discrepancies, illustrating his statements by examples. He likewise adverts to their modes of living, their actions, habitations, and various functions. Many of his physiological facts appear to have been ascertained by accurate observation; and several of his positions, which were once deemed fabulous or erroneous, have been found, on mature inquiry, to be strictly consistent with the phenomena of nature. He is supposed either to have dissected the bodies of animals with his own hands, or, at least, to have assisted at the dissection of many. When we reflect on such a rare combination of perspicacity, unwearied diligence, and highly favourable opportunities of acquiring an intimate acquaintance with the details of his subject, we need not wonder that many of his observations should stand the test of severe scrutiny, and that the student of natural science should still approach with reverence the relics of a system once reared under the most flattering auspices.

The Natural History of Pliny has been styled the *Encyclopædia of the Ancients;* and it may, in fact, be regarded as the depository of the physical, astronomical, geographical, and medical knowledge of the age in which it was composed. The multitude of authors whom he quotes, attests the variety and extent of his information; and we learn from himself, that his materials were extracted from two thousand volumes. The preface or dedication of this celebrated production is addressed to Vespasian; and, though not destitute of every symptom of pedantry and conceit, bears all the internal marks of genuineness. The authenticity of the first book, however, which is little more than a table of contents and authorities, is much more questionable. The work itself is, in one sense, strictly methodical, commencing with a general view of the universe, then passing from a geographical survey of the terraqueous globe to the history of man, of terrestrial and aquatic animals, of the vegetable and mineral kingdoms, of the materials of pharmacy and the arts, and embracing a rich variety of collateral and incidental topics. The whole performance, even in some of its less inviting departments, is sprinkled with anecdotes and philosophical reflections, which cannot fail to be more or less pleasing to the modern reader. Although large portions of the work can be regarded only as compilations, or rather as translations from the writings of Aristotle and other authors, yet the general arrangement, several of the details, and a style more abrupt and nervous than pure and correct, may lay claim to originality and dignity of manner. On various occasions, we may remark a striking combination of scepticism and credulity; but the author's marvellous recitals generally rest on the testimony of others, while his personal observations are faithfully recorded, and he betrays no intention of wilfully misleading his readers. It has likewise happened to Pliny as to Aristotle, that some of his assertions, formerly regarded as unfounded, have been, more recently, corroborated by facts.

Ælian's work *On the Nature of Animals* consists of seventeen books; but it is devoid of every principle of arrangement, and manifests a uniform disregard of nomenclature and accurate description. The writer's aim, indeed, appears to have been, to paint the manners and dispositions of various animals, with a reference more or less pointed to the moral qualities of man. With some undoubted facts he mingles many fictions; but for these last he frequently cites his authority, or else he wishes it to be understood that he does not himself believe them.

Oppian, in his *Cynegeticon*, pourtrays many of the quadrupeds in lively colours; nor does he confine himself to description alone, but frequently characterises the manners, dispositions, and economy of the different species which he introduces into his poem. While the nature of his undertaking precluded his adherence to systematic order, he nevertheless evinces an acquaintance with the principles on which systems are founded. It is, moreover, worthy of remark, that though endued with a warm poetic fancy, he rejects most stories that savour of wonder and romance.

In the middle ages, we meet with no works relative to our present subject that need to detain us; but, early in the sixteenth century, the name of *Conrad Gesner* solicits our grateful commemoration. Notwithstanding the natural weakness of his constitution increased, it is alleged, by the experiments which he made on himself, and notwithstanding the limited term of his existence, for he died of the plague in the 49th year of his age, the extent of his researches and the complication of his labours, would reflect no discredit on a busy life protracted to a century. Beza hesitates not to say, that Gesner possessed the combined knowledge of Pliny and Varro; and the illustrious Boerhaave emphatically styles him *a monster of erudition.* His bodily infirmities did not discourage him from making frequent and painful Alpine excursions; and though, at times, constrained to write for bread, he continued to found and support a botanic garden, retained in his service a painter and an engraver, collected a very considerable library, and, according to Haller, was the first who formed a regular museum of natural history. In spite of the disadvantages under which he laboured, he applied to the study of nature, in its various branches, and with such assiduity, that he restored the science which he cultivated to the dignity of philosophy, a character of which it had almost lost sight since the days of Aristotle. Besides other learned and extensive works, he published a History of Animals, in four folio volumes, an elaborate and somewhat ponderous union of compilement and commentary, containing almost every thing that had been collected on the subject by ancients and moderns, by poets, physicians, and grammarians, interspersed with many amusing and not a few fabulous anecdotes. In the subdivisions of his classes, he was unfortunately regulated by the letters of the alphabet, that he might more conveniently introduce his philosophical observations, which he regarded as the most valuable portion of this extraordinary performance.

His contemporary *Aldrovando*, Professor of Botany in the University of Bologna, devoted his time, his talents, and his fortune, to the prosecution of natural science, in all its departments, and with a degree of assiduity and preseverance which has few parallels in the annals of literature; for he visited different countries with the sole view of becoming acquainted with their natural productions, and he employed, for upwards of thirty years, some of the principlal designers and engravers of Europe. His collections in natural history laid the foundation of that museum, which still forms one of the most conspicuous objects in the university of Bologna. His classification of quadrupeds, though, in some respects, inaccurate and unphilosophical, is by no means contemptible for the age in which he lived. The descriptions are generally faithful; but the historical passages are often debased with fable and superstition, and the style is deeply tinctured with the pedantry and false taste of the times. Of the thirteen folio volumes which bear his name, only the first six were published by himself, and the remainder by various learned editors, who selected the materials from the mass of manuscripts, which their author had bequeathed to the Senate of Bologna. We cannot dismiss the names of Gesner and Aldrovando, without remarking, that these indefatigable compilers laid a broad foundation, which has contributed to support the fair and ample superstructures of subsequent ages, and that, in consideration of the important services which they have rendered to natural history, it behoves us to touch on their errors and imperfections with the utmost lenity of criticism.

In the natural history of *Johnston*, a learned Polish physician, who traversed most of the countries of Europe, the subdivisions of the quadrupeds differ in some respects from those of Gesner and Aldrovando; yet his book is little else than an abridgment of their more massy labours, with the addition of the American animals borrowed from Piso and Marcgraaf. In the condensation of his materials, Johnston has manifested both ability and taste; but he has still retained a portion of the fiction which dims the lustre of his prototypes.

The worthy and celebrated Ray, having devoted fifty years of his studious life to the cultivation of natural science, reformed zoology in most of its departments, presented it in an advantageous point of view, and contributed more to its improvement in his own country, than any of his predecessors. He invented and defined many terms, expressive of ideas before unknown to the naturalists of England, and he introduced many others from writers of the first eminence. As he wrote Latin in great purity, and with much facility, he gave to his subjects all the embellishment which polite learning could bestow, while his extensive erudition, and his knowledge of philosophy at large, enabled him to add many collateral ornaments, and useful observations, with an aptitude of judgment which has been much applauded. The consideration of his distribution of quadrupeds would lead us beyond the narrow bounds assigned to the present sketch, and will be best apprehended by consulting his *Synopsis*; a work which sufficiently bespeaks his love of order and method. Qualities, however, of a higher cast powerfully recommend his synoptical treatises to our careful perusal; for his descriptions, though short, are perspicuous and comprehensive, and, not unfrequently, enlivened by concise and interesting notices of the manners and dispositions which characterise particular species. Even learned foreigners have been eloquent in the praise of Ray; and the advocates of civil and religious liberty will bestow their unqualified admiration on that fine passage in which he expresses his joy and gratitude at having lived to see the accomplishment of the Revolution.

The next distinguished contributor to the methodical arrangement and description of the mammiferous animals, to whom we shall advert, is the justly celebrated Linne. The life and writings of this illustrious naturalist form the subject of an ample and interesting volume; but here we can only point to those parts of his works which professedly illustrate his first class of animals. In his Swedish *Fauna*, the quadrupeds of his native country are delineated in a manner at once concise and comprehensive; and the work has been pretty generally followed as a model of similar undertakings. The three volumes of his *Systema Naturæ*, published at Stockholm, in 1766, 67, and 68, are to be considered as having received the author's finishing hand, and as forming the twelfth edition of a work which is scarcely paralleled by any effort of the learned. The *Mammalia*, which constitute his first *Class*, he divides into seven *Orders*, the distinctions of which are established principally on the difference in the number, situation, and form of the three kinds of teeth, namely, the *primores*, or *incisores*, commonly called *fore-teeth* or *cutting-teeth;* the *laniarii*, or *canini*, *lacerating*, *canine*, or *dog-teeth;* and the *molares*, *double*, or *grinding teeth*.

1. The first Order is denominated *Primates*, and includes animals furnished with cutting-teeth, the four above being parallel. 2. *Bruta*, which are destitute of fore-teeth. 3. *Feræ*, with six sharpish fore-teeth in the upper jaw, and one canine tooth on each side. 4. *Glires*, with two fore-teeth in each jaw, and set close to one another, but remote from the grinders, and no canine teeth. 5. *Pecora*, which have no fore-teeth in the upper jaw, but six or eight in the lower, very remote from the grinders, the feet hoofed, and the mammæ inguinal. 6. *Belluæ*, having the fore-teeth obtusely truncated, and the feet hoofed. 7. *Cete*, with breathing apertures on the head, pectoral fins, and a horizontal caudal fin. These orders are distributed into *Genera*, or families, with abbreviated artificial characters attached to each. Under the exposition of each genus is ranged that of the several species which it comprehends, with their varieties, when any such are known to exist. Gmelin, and others, have improved or modified the details of the Linnéan nomenclature and divisions.

Jacob Theodore Klein has left scarcely any part of zoology untouched, and has treated its divisions both in a systematic and physiological manner; but, though he was one of the most ingenious of the opponents of Linné, his own principles of arrangement are so limited, that very incongruous animals are often classed together.

His name, however, was soon nearly eclipsed by that of the *Count de Buffon*. The latter, in the more minute and anatomical details of his History of Quadrupeds, derived important aid from the labours of Daubenton. A wilful disregard of methodical arrangement, and a love of visionary speculation, unfortunately pervade the Count's enchanting pages. When we add, that he frequently betrays more credulity than is consistent with the philosophical character; that he has, in several instances, though inadvertently, misstated facts, or maintained contradictory positions; and that he has occasionally indulged in a pompous inflation of style, which ill accords with the simple majesty of nature, we have, perhaps, enumerated most of the defects with which, as a writer, he is chargeable. These, however, are, in no small degree, redeemed by many faithful and animated portraits, by accuracy of description, and glowing eloquence. The circumscribed nature of our plan permits us not to particularize the various merits of the editors and continuators of his great and splendid work; such as Castel, and especially Sonnini, whose enlarged edition of the History of Quadrupeds forms the most complete store of elegant information with respect to the subject of the present article. Yet, as often as we have resorted to this valuable repository, we have regretted the want of preliminary views, and of a general analytical index.

Mr. Pennant, both in his Synopsis and General History, has ably and agreeably illustrated the class of animals which we have now to consider. In his arrangement, this respectable author has chiefly followed the divisions of Ray, with certain modifications and improvements, suggested by more recent observations and discoveries. It is, however, to be lamented, that his engravings are, for the most part, meagre and defective.

Another British naturalist, whose general Zoology we have had frequent occasion to consult, is the late Dr. Shaw, of the British Museum. His account of the Mammalia is at once scientific and popular, and illustrated with such figures as convey clear ideas of the animals described. His method is avowedly founded on that of Linné, but embraces such corrections and enlargements as the progressive state of natural history may be expected to have supplied. The discrimination with which he has selected his materials; the diffidence with which he records doubtful allegations; and his respectful intimation of the sources whence he derives his knowledge, all entitle him to no common praise. If a want of general and introductory discussion; if occasional dryness, arising from the monotony of curtailed description; and if a few neologisms, or harsh combinations of language, should be thought to detract from his merit, that merit is, nevertheless, of a superior cast, and sufficiently proves, that he had ably availed himself of his talents and opportunities, to delineate the history of those tribes of beings, which partake of the physical destinies of man, and which have proceeded from the grand and common source of creative power and goodness.

The mere English reader may also draw both useful and agreeable instruction from Bewick's *General History of Quadrupeds*, Church's *Cabinet of Quadrupeds*, Kerr's *Edition of the Linnéan System*, *a New System of the General History of Quadrupeds*, in three volumes; that part of Goldsmith's *History of Animated Nature*, which treats of the mammalia; the first volume of Bingley's *Animal Biography*; and the account of *British Quadrupeds*, by the same considerate and entertaining writer. But the more learned and curious student of mazology, will, moreover, have recourse to Pallas' *Novæ Species Quadrupedum*, *Histoire Générale et Particulière, pour servir à l'histoire des Animaux Quadrupedes*, the *Dictionary of Quadrupeds*, which makes part of the *Encyclopedie Methodique*, and a great variety of communications in the transactions of the learned academies and societies of Europe, which it would be tedious to enumerate. In the valuable catalogue of Sir Joseph Banks' library, he will find the title of almost every literary contribution of name to the subject now before us.

For the ANATOMY and PHYSIOLOGY of the MAMMIFEROUS CLASS of ANIMALS, see the articles ANATOMY COMPARATIVE and PHYSIOLOGY.

In our divisions and subdivisions of this class, we shall be chiefly guided by the arrangements proposed by Cuvier, Lamarck, Dumeril, and Desmarest, with occasional reference to the corresponding Linnéan titles and designations, which are still the most popular in this island, and which include the names invented or adopted by Linné himself, or by some of his followers. Although the classification and nomenclature of the productions of nature, or of any portion of these productions, may be founded on principles more or less philosophical, yet we should regard them as mere devices of expedience, as contrivances to facilitate our apprehension of their properties, and to aid the memory in recalling their distinctive characters, rather than as a series of lines of demarcation unequivocally expressed in the existing system of things. Without, therefore, previously expounding, in all its formality of detail, the methodical distribution which we have been induced to adopt, we shall be contented to unfold it gradually in the sequel, thus endeavouring to relieve the irksomeness of technical definitions by the more interesting topics of specific illustration. Even these latter we are imperiously constrained to exhibit in a much more contracted form than we could have wished, or than a mature review of the subject would require. A large volume, in fact, would scarcely suffice for its discussion; but even a mere outline may satisfy the curiosity of some, and contribute to stimulate and guide the further inquiries of others.

In pursuance of our plan, then, we proceed to state, that all mammiferous animals with which we are acquainted, may be conveniently arranged under three primary divisions or sections, namely, the UNGUICULATED, UNGULATED, or HOOFED, and the NECTOPODE, or FIN-FOOTED.

I. The UNGUICULATED MAMMALIA have the upper surface of the extremities of their fingers, or toes, furnished with a thin horny fence, or covering, called a *nail*. These, again, may be divided into the *toothed* and the *toothless*; and the former into those which are provided with incisive, canine, and grinding teeth, and those which want at least one of these sorts of teeth. They include several orders and families.

I. ORDER, BIMANA, or TWO-HANDED. This title is founded on the distinction of a separation of the thumbs from the fingers, at the two upper extremities only, and, consequently, includes the single genus *Homo*, or *Man*. But the consideration of his structure belongs to anatomy, the derangements of his organization to medicine, and the nature and record of his social institutions, with the principles and duties originating in his relations and destinies, respectively, to civil history, ethics, and theology. Waiving, therefore, in this place, any further notice of the first, we pass to the

II. ORDER, denominated QUADRUMANA. The animals belonging to it have their thumbs, or great toes, separated at the four extremities, and thus comprehend the greater number of the Linnéan *primates*.

The *first family* of this second order consists of the *Simiæ*, or the numerous tribe of *monkeys* and *apes*. These are, in general, characterized by having their teeth disposed nearly in the same manner as those of the human species, except that the canine are much longer in proportion. They are distinguished from the human form by the narrowness of the pelvis, the flatness of the nose in most instances, and the want of apparent lips, chin, and calves of the legs. They have clavicles in the skeleton, a very lengthened and falciform shoulder-blade, weak muscles in the thighs and legs, generally long arms and fingers, very short thumbs, and rarely either buttocks or prominent heels. Some are destitute of a tail, while others have that appendage very long, and others, again, have it *prehensile*, or fitted for laying hold of objects. Some are remarkable for callosities behind, others for cheek-pouches, and others for thyroidian sacs. They have two pectoral teats, and genital organs resembling the human. For the most part they rest only the outer margin of their feet on the ground.

These animals chiefly affect the countries which are situated between the tropics, abounding in the woods of Africa, in India and its islands, in the south of China, and Japan, and in the American continent, from the isthmus of Darien to the province of Paraguay. One or two species also occur in Arabia and Barbary, whence they have been conveyed to Gibraltar. It is worthy of remark, that apes and monkeys occupy the same line on the two continents, and there live, as in colonies, each species in its respective haunt and district of forest, without disturbance or confusion, and without invading the property of one another. The parrots and their congeners fly about under the same foliage, as if nature had intended to bring together the only quadrupeds which resemble man, and the bird which most readily imitates his voice. Who would not wish to contemplate, in the ancient forests of America, those troops of Simiæ, which flit from branch to branch, swing with their prehensile tails, assume a thousand grotesque attitudes, and leap, spring about, and mutter, as if they meditated some important enterprize, while flocks of parrots and parokeets alight among them, chatter in the branches, and toss about their heads, which sparkle in the rays of a dazzling sun?

The Simiæ are a very suspicious race, and endowed with a very retentive memory. Their sense of touch is particularly delicate; they use their arms in swimming; they are lively, agile, frolicsome, and addicted to gesticulation and mimicry, while, owing to their physical organization, they have many actions in common with mankind. Many of them are fierce and intractable, while others manifest a degree of attachment to those who are kind to them, though not always unmixed with symptoms of a petulant and mischievous disposition, betraying, at the same time, an utter disregard of our ideas of cleanliness and decency. They are nimble in their movements, and they express, by very unequivocal looks and gestures, their feelings of irritation or delight. There are times when the most melancholy man cannot refrain from smiling at the playful absurdities of a monkey. Habits of domestication may regulate, or counteract, but are, perhaps, inadequate to extinguish the native character and propensities of the tribe. Few individuals have hitherto succeeded even in correcting the wanton carriage of some of the baboons; and the wanderoo, in confinement, ceases not to be forward, sly, knavish, and satirical. It is true, at the same time, that he may be taught a great variety of feats, such as dressing himself, kindling the fire, scouring plate, rinsing glasses, beating on the drum, dancing on the tight rope, &c. During the residence of Messrs. Condamine and Bouguer in Peru, some tame apes had so accurately watched the proceedings of these philosophers, that in their pantomimic exhibitions, they enacted the placing of signals, running up to a time-piece, taking notes with a pen, and viewing the stars through a telescope. The Indians and negroes sometimes turned this talent for mimicry to their own account: when, for example, they cannot easily reach to the pepper and the cocoa-nuts of the higher branches, they pluck off those near the ground, and, like children at play, ranging them in a circular form, retire. The monkeys immediately repeat the process, and rest not till they have stripped all the branches, and deposited the produce according to the pattern, whilst all the circles are swept away during the night. With a view to ensnare the animals themselves, a man will sometimes dip his hands in cups filled with water, or honey, with which he smears his face, and adroitly leaving similar vessels containing bird-lime, or some other viscous matter, withdraws to a hiding-place. The monkeys immediately approach the cups, and attempt to perform the same ceremony, when they get blinded and entangled. They are also occasionally decoyed by a person who pulls off and on a boot, for several times in succession, and leaves it duly lined with some tenacious substance, when they are anxious to try how it fits. It is remarkable, that most of them are extremely fond of mustard, tobacco, and even snuff, which last they eat greedily, without seeming to suffer any inconvenience. They are susceptible of small-pox and measles. In the gall-bladders of a few of the species, are occasionally found biliary concretions, to which many virtues have been foolishly ascribed, and which the Indians, according to Tavernier, sell for more than a hundred thousand crowns each, prohibiting their exportation, and reserving them as presents for ambassadors. The various kinds of monkeys and apes are the prey of leopards, and other species of the feline tribe, as well as of serpents, some of the larger of which pursue them even to the tops of trees, and by means of their extensile jaws, swallow them entire.

Although the flesh of monkeys is tough, and said to be astringent, it is, nevertheless, held in high request by some savage hordes, and even by Europeans in Cayenne and other countries; but persons of refined manners are averse from partaking of a dish which bears a striking resemblance to a dead child.

Notwithstanding the many species of Simiæ which have been particularized, there can be little doubt that many more remain to be unfolded. Humboldt, indeed, who had occasion to observe the American varieties, hesitates not to conjecture, that those already discriminated do not constitute one-eighth part of the family. Bosman alludes to fifty species on the gold coast alone; while Condamine assures us, that it would require a volume to discriminate those which frequent the banks of the Amazons. It is no easy task, however, to settle with accuracy the several species and varieties even of those which have been observed, because there is reason to believe that several of them sexually intermingle, and thus, as in the canine race, occasion numberless gradations, and, in course, considerable confusion in the arrangements and descriptions of naturalists. Apparent varieties have likewise proceeded from habits of domestication, and from the devices of show-men, who aim only at singularity of appearance, and are thus sometimes instrumental in misleading the natural historian. Some of the species, too, have been so imperfectly examined and described by travellers, that their accounts should be received with caution and distrust. For a more ample exemplification of this family of animals than our very circumscribed limits permit us to exhibit, we beg leave to refer the curious reader to Audebert's *Histoire Naturelle des Singes*.

The first genus of Simiæ which attracts our attention, is the PITHECUS of Cuvier, which comprises the *orangs*. Its characters are, head rounded, facial angle of 65 degrees; body almost perpendicular; four incisive, two canine, and ten grinding teeth, in each jaw; no cheek pouches or tail; thyroidian sacs, which inflate with the passage of the air from the larynx, and thus preclude the enunciation of articulate sounds; arms very long; nasal orifices very low, and separated by a very slender septum. The known species, which do not exceed six in number, all inhabit the warm countries of the old continent. The substitution of *simia* for *pithecus* gives the Linnean designation of each, with one exception.

* 1. *P. satyrus*, *oran otang*, *orang outang*, *little jocko*, &c. of the French naturalists. Plate CCCLIII. Fig. 1. Tailless, chesnut or dark-coloured, haunches naked, and the hair on the lower part of the arms *reversed*, *i. e.* turned up towards the elbow. 2. *P. lar*, *great gibbon*, or *long armed ape*. Haunches naked, and the arms as long as the body. 3. *P. troglodytes*, *pongo* of Audebert, *drill*, or *Angola ape*. Head conical, body brawny, back and shoulders hairy, rest of the body smooth. 4. *P. malacensis*. So we have ventured to denominate the *little gibbon* of Buffon, and others, which is variety 2d of Linné's *simia lar*, and differs from the preceding, not only in being a third less in its dimensions, but also in the colour of its hair, which is greyish-brown, and of a darker shade on the shoulders, and along the ridge of the back. 5. *P. cinereus*, *simia molock* of Audebert, *cinereous gibbon*, *wouwou*, or *molock*. Tailless, haunches naked, arms as long as the body, hair of a bright ashen hue. * 6. *P. sylvanus*, *chimpanzee*, *jocko*, or *pigmy ape*. Haunches naked, head roundish, arms short. Of these, two or three may, perhaps, be only varieties; but this point cannot be distinctly ascertained, until long and familiar observation has determined whether the characters which we have just noted be permanent or accidental.

* 1. *P. satyrus*. *Orang outang*, or *oran otan*, in the Malay language, is said to signify *wild man*, or *being of intelligence*. The specimens of this animal which have been brought into Europe were mostly young individuals, seldom exceeding three feet in height; but it is alleged, that when they have attained to maturity, they equal, or even surpass man, both in stature and strength. The body is thinly sprinkled with hairs of a rusty brown, and scarcely an inch long; the ears, hands, and feet, nearly resemble those of man; and, indeed, the whole external appearance approaches more than that of any of the ape tribe to the human form. There are several points of difference, however, in respect both of external and internal structure, such as the marked disproportion between the length of the arms and thighs; the greater flatness of the nose; the smaller interval between the eyes, and the greater between the nose and mouth, than in the human countenance. The form of the feet, too, is very dissimilar, the toes of the orang being much longer, and the great toe farther separated from the others; the thumb likewise is much smaller, and the palm of the hand longer and narrower. In place of twelve, the orang has thirteen ribs; its vertebræ are shorter than in the human subject; the bones of the pelvis narrower; the orbits of the eyes deeper; the kidneys rounder, and the urinary and gall-bladders longer and smaller. The position of the occipital aperture is more backward in the orang than in the human subject; the insertion of the flexor muscles is lower; the jawbone is divided by a suture, and, as in its congeners, the nail of the great toe is wanting. In short, from the conformation of the larynx, and the structure of the muscles, as well as from the whole frame of the bones, this creature was evidently not destined to walk erect. "I have many reasons," says Goldsmith, "to believe, that the most perfect of the kind are prone, like the rest of the quadruped creation, and only owe their erect attitude to human education. Almost all the travellers who speak of them, mention their going sometimes upon all fours, and sometimes erect. As their chief residence is among trees, they are, without doubt, usually seen erect while they are climbing; but it is more probable that their efforts to escape upon the ground, are by running upon the hands and feet together. Schouten, who mentions their education, tells us, that they are taken in traps, and taught in the beginning to walk upon their hind legs, which certainly implies, that, in a state of nature, they run upon all fours. Add to this, that when we examine the palms of their hands and the soles of their feet, we find both equally callous and beaten; a certain proof that both have been equally used. In those hot countries, where the apes are known to reside, the soles of the negroes feet who go barefoot, are covered with a skin above an inch thick, while their hands are as soft as those of an European. Did the apes walk in the same manner, the same exercise would have furnished them with similar advantages, which is not the case. Besides all this, I have been assured, by a very creditable traveller, that these animals naturally run in the woods upon all fours; and when they are taken, their hands are tied behind them, to teach them to walk upright. This attitude they learn after some time; and, thus instructed, they are sent into Europe, to astonish the speculative with their near approaches to humanity, while it is never considered how much has been acquired in the savage schools of Benin and Angola."

The orang outang inhabits the deserts of interior Africa, Madagascar, some parts of the East Indies, and particularly the island of Borneo. In its wild state, it subsists principally on fruits, haunting the forests of lonely regions, and making its resting-place on trees, where it is secure from all its enemies except serpents. A full-grown individual is seldom taken alive, especially as they usually roam in companies, and armed with thick clubs, with which they hesitate not to attack the fiercest opponent. In the woody regions, on the banks of the Gambia, they move in very extensive bands, headed by the larger ones, and betray much petulance and malignity. Their habitations, composed of plants and branches of trees, so thickly matted as to exclude the vertical rays of the sun, have been found in some of the woods; and the ground was observed to be beaten smooth about their paths and dwellings. Gemelli Carreri informs us, that, when the mountain fruits are exhausted, these apes frequently descend to the sea-coasts, to feed on shell-fish, particularly on a large species of oyster, which commonly lies on the strand with its shell open. Fearful, however, of its closing on their paws, they introduce a pretty large stone between the valves of the shell, and then drag out its contents, and devour them at leisure. Their characteristic proneness to imitation, and their susceptibility of learning lessons, render it sometimes difficult to discriminate between those traits of their conduct which result from original, and those which are the consequence of acquired habits.

Dr. Tyson, who describes the anatomy of a young orang outang, which was exhibited in London about the end of the seventeenth century, observes, that it was of gentle and affectionate dispositions, and that it embraced its shipmates with the greatest tenderness. After it was accustomed to wear clothes, it became very fond of them, and would partly dress itself, and partly take the assistance of others. The individual of this species described by Buffon, had a melancholy deportment, and would walk on two legs even when it carried burdens. It would give its hand to show the company to the door, sit at table, unfold its napkin, eat with the fork and spoon, pour out its drink into a glass, *hob and nob*, take a cup and saucer, set them on the table, put in the sugar, pour out the tea, let it cool before sipping it, &c. It approached strangers with respect, and rather to receive caresses than to offer injuries. It continued only one summer in Paris, and died in London, owing, it was supposed, to excessive indulgence in sweet-meats. That which was imported into Holland in 1776, and which is so pleasingly described by Vosmaer, was also fond of human society, and warmly attached to those who had the daily care of it. When they retired, it would often throw itself on the ground, as if in despair, utter lamentable cries, and tear in pieces the linen within its reach. It would frequently take the hay from off its bed, inviting its keeper by signs to be seated near it. Having, one morning, got free from its chain, it mounted with great agility to the rafters of the house, and required the assistance of four men to secure it. In the course of that day's ramble, it had, among other feats, uncorked a bottle of Malaga, drunk off the wine to the last drop, and set the bottle in its place again. Though it had an indiscriminate appetite, it manifested a preference to sweet roots and fruits, to aromatic herbs, and to the leaves and roots of parsley. When presented with a plate of strawberries, it took them up, one by one, with the fork, and put them to its mouth, holding, at the same time, the plate with the other hand. Its ordinary drink was water; but it was partial to wine; and it would make the proper use of a tooth-pick. On ship-board it amused itself with the sailors, and, like them, repaired to the kitchen for its stated portion of food. At night it prepared its bed by shaking and arranging the hay on which it reposed; and it drew the coverlet over its body. By making use of a bit of stick for a key, it attempted to unlock its chain. It survived its removal to Holland only seven months; and its stuffed remains were deposited in the Museum of the Prince of Orange.

We learn from Pyrard, that the orang outangs of Sierra Leone are robust and well formed; and that, in consequence of feeding and training, they are taught to perform various menial offices, as pounding in a mortar, or fetching water in small pitchers, which they carry on their heads, but suffer to fall, if not soon taken from them at the door of the house. Pyrard's statements derive confirmation from Barbot, who assures us, that these animals are frequently serviceable in the settlements on the Guinea coast, by being drilled to turn the spit, and watch the roasting of the meat, which they do with considerable dexterity and address. M. Grandpré, a French naval officer, relates, in like manner, many surprising anecdotes of a female orang which he saw on board a slave-ship. It was bred to heat the oven, remove fallen embers, and assist in navigating the vessel, mounting aloft, and descending on deck, with more alertness than any of the ship's company. Notwithstanding its acquirements and social dispositions, which rendered it a general favourite, the mate treated it with such marked cruelty, that it at length obstinately refused all manner of food, and died of hunger and a broken heart.

Father Caubasson had so won on the good graces of a young orang outang, that whithersoever he went, it was desirous of accompanying him, insomuch that when he had to officiate on Sunday, he was obliged to confine it. On one occasion, however, it had contrived to make its escape, and, silently mounting on the sounding-board, lay perfectly quiet, till the sermon commenced. It then crept to the edge of the board, and, overlooking its master, counterfeited all his gestures in so grotesque a style, as to excite the risible faculties of the audience. The preacher, surprised and confounded at such unseasonable levity, had recourse to reproof, but without effect, when, redoubling his vociferations, the mimic continued to act its part with such ludicrous accuracy, that the congregation gave way to loud and reiterated laughter. A friend now stepped up, and explained the adventure, when the good humoured Father found no small difficulty in preserving his own gravity.

In the 14th vol. of the *Annales du Muséum*, M. Frederic Cuvier gives a minute account of a female orang, which was only fifteen or sixteen months old when she reached Paris, and which had contracted a great degree of debility and languor by crossing the Pyrenees in cold weather. During the first week after her embarkation at the Isle of France, she betrayed evident apprehensions for her safety, and seemed greatly to exaggerate the dangers of the rolling of the vessel, never venturing to walk without firmly grasping the ropes, or some support. Having, from affection, followed M. Decaen up the shrouds, she afterwards repeated the experiment with more confidence. At meal times, she used to leap up behind this gentleman's chair, for such morsels as he thought proper to give her. On his arrival on the coast of Spain, however, when he happened to go on shore, and another officer supplied his place at table, she, at first, placed herself on the back of the chair, as usual; but no sooner perceived a stranger, than she refused to be fed, threw herself on the floor, and rolled about in great distress, frequently striking her head, and roaring piteously. When shut up in a closet, she climbed on a chair that stood near the door, which she opened by lifting the latch. To prevent a repetition of this manœuvre, the chair was removed to some distance from the door. but she succeeded in pushing it back, and thus again made her escape. Can we refuse to ascribe such proceeding to some higher principle than mere blind or mechanical instinct? As this young creature had not acquired much expertness in eating at table, she compensated for her awkwardness by her ingenuity; for, when the meat on her plate did not lie convenient for her spoon, she handed the latter to the person next her to have it filled. She drank very well from a glass, which she could hold in her two hands. On one occasion, after having put it down, observing that it was just going to fall, she saved it by clapping her hand to the inclining side.

We have reason to believe that these apes were not unknown to the ancients, and that they are described in the Periplus of Hanno, as hairy animals resembling men. When the people attempted to hunt them down, they were assailed with stones, and proved unequal to securing the males, which escaped among the precipices. The three females which were captured were so fierce and mischievous, that they were speedily killed. At the distance of two centuries, when the Romans demolished Carthage, the stuffed skins of these animals were found preserved in the temple of Juno. We may also note, in passing, that this family of the ape tribe probably suggested the woodland machinery of fawns and satyrs. Even in a very remote period, the prophet Isaiah, when he pourtrays, with such graphic effect, the desolation of the great Babylon, introduces satyrs dancing among the ruins.

In reply to those gloomy or fanciful writers, who seem to take a pleasure in degrading their own race.

and who represent the orang outang either as a degenerate man, or as the source of all the varieties of the human species, we shall only beg leave to remark, that, although the mere circumstance of anatomical organization may enable it to imitate, with a certain degree of facility, nay, may constrain it to adopt several of our actions and gestures, it never has been taught the use of articulate speech ; that, in regard of intellectual endowments, it is, probably, much inferior to the beaver, the dog, the horse, or the elephant ; that it is incapable of subsisting in every diversity of climate ; and that it is devoid of the sentiment of religion.

* *P. sylvanus.* The pigmy ape inhabits Africa, the East Indies, and Ceylon, is about the size of the domestic cat, and, when standing on its hinder legs, measures about two feet in height. Its long and wrinkled face imparts to it, however young, the semblance of old age. Its canine teeth are shorter than those of its congeners, and, like the ears, very much resemble those of man. The eyes are round, reddish, and lively. The usual colour of the body is olive-brown above, and yellowish beneath, and, in many individuals, part of the breast and belly is covered with a large patch of black.

The female seldom produces more than one at a birth ; and no sooner is the little creature born, than it climbs on the back of its dam, and clasps close to its neck, by which means it is transported from place to place.

Pigmy apes abound in the forests of Bongie, Cole, and Stora, districts of ancient Numidia, where they sometimes cover whole trees, subsisting on pine cones, acorns, nuts of various kinds, Indian figs, melons, and a great variety of vegetables and insects. Like others of their family, they often congregate in numerous bands, to pillage gardens and plantations, in which they are apt to commit great havoc, destroying more than they devour. Previously to commencing a predatory excursion, they dispatch one of their party to the summit of some adjoining rock, or to the top of a tree, to give notice of danger, and whose shriek is the signal of retreat. They employ their hands and feet with much address, either in laying hold of objects within their reach, or in attempts to untie the cords with which they are detained in confinement. They are, naturally, sprightly and playful, and express pleasure by incessant chattering. In their general dispositions, they are so mild, that they may be tamed without difficulty; but, when irritated, they have recourse to threatening gestures, and will bite in self-defence. They recollect for a great length of time the persons of those who injure them ; but to those from whom they are accustomed to receive kind attentions, they become so much attached, that they will follow them with the fidelity of a dog. Yet, in their habits, they are dirty and loathsome ; and nothing short of severe chastisement can restrain them from breaking or destroying every thing on which they are capable of making any impression. Their fondness for eggs probably gave rise to the ancient fable of the wars between the Pigmies and Cranes.

2. Genus **Callithrix** of Cuvier, and *Sapajou* of some of the French naturalists. Upper part of the head flattened, facial angle 60 degrees, four incisive, two canine, and twelve grinding teeth in each jaw, tail very long and prehensile, no cheek pouches, nostrils widely separated, arms proportioned to the legs, nails long, compressed, and not hooked. The five species, of which the Linnéan trivial appellations have been retained, are resident only in South America.

* 1. *C. paniscus Coaïta* of Audebert, or *Four-fingered Monkey.* Tailed, black, without beard or thumbs, 2. *C. capucina*, *Saï*, or *Capuchin Monkey.* Long-tailed, beardless, without callosities, crown and limbs black. 3. *C. fatuellus*, *Sajou cornu* of Buffon, or *Horned Monkey.* Long-tailed, beardless, with two horn-like tufts on the head. 4. *C. apella*, *Sajou brun* of Buffon and others, *Brown Sajou*, or *Weeping Monkey.* Tailed, beardless, body brown, nails flat and round, legs black. 5. *C. sciurea*, *Jaïmiri* of the French, *Squirrel*, or *Orange Monkey.* Tailed, beardless, hind part of the head prominent, with orange-coloured hands and feet, four of the smaller claws pointed.

* *C. paniscus.* Length, from the extremity of the muzzle to the rump, about eighteen inches, and that of the tail nearly two feet. The hands, or fore feet, are distinguished from those of every other species by the want of a thumb, whose place is indicated by a sort of tufted substance. Notwithstanding the air of melancholy which seems to be impressed on its countenance, it is extremely lively, and even frolicsome, animating, by its frequent and sportive movements, the dreary forests of South America. That which Buffon saw at the Duc de Bouillon's, was a general favourite, on account of his familiar and endearing behaviour. But, in spite of all the care and attention with which he was treated, he fell a sacrifice to the rigorous cold of 1764. Others of them have been known to evince, on particular occasions, that malicious sagacity which seems to be inherent in the race. When beaten, they will sometimes climb up a lemon, or an orange tree, and, if chased, will pluck off the fruit, and throw it, with singular dexterity, at the head of their pursuer. Though troops of them will sometimes venture to attack a single traveller, they are greatly terrified for dogs, whose presence they sedulously avoid ; and the discharge of a musket puts a whole company of them to immediate flight. They possess, it should seem, but a very moderate share of real bravery ; for, though addicted to skirmishing, they always scamper off on the approach of danger. They often make odd grimaces at travellers, and endeavour to sprinkle them with their urine. When engaged in plundering expeditions, they station sentinels on the adjacent heights ; and when they want to pass along the tops of trees that are separated beyond leaping distance, they will hang down, linked to one another by the tail, and swing in this state, till the lowest catches hold of a bough of the next tree, from which it draws up its companion. In the body of this species, whether the animal happens to die in confinement, or is killed in its native woods, there is usually found a long thin worm, probably one of the *tæniæ*, besides many smaller kinds in the intestines. The female produces one or two young, which often cling to her back.

3. Genus **Pithecia** of Desmarest. Corresponds with the preceding genus, except that the animals belonging to it have a very bushy tail, which is not prehensile.

1. *P. Saki*, or *Fox-tailed Monkey.* Blackish brown, with the tips of the hair whitish. 2. *P. leucocephala*, *White-headed Monkey.* Hair of the head white.

4. Genus **Cebus**, *Sagoin* of La Cépède. Tail very long, slender, hairy, and not prehensile ; nails of the fingers and toes much hooked and pointed, those of the

great hind toes flat, grinders with sharpish tubercles, ears much extended; the other characters coincident with those of *Callithrix*.

1. *C. Midas*, *Tamarin* of Buffon and Audebert, *Midas Monkey*. Beardless, upper lip cleft, ears square, feet naked, and saffron-coloured. 2. *C. argentata Mico* of Buffon and Audebert, *Fair Monkey*. Long-tailed, beardless, white, with red face, and brown tail. * 3. *C. Oedipus*, *Pinche* of the French, *Red-tailed*, or *Little Lion Monkey*. Red-tailed, beardless, hair of the head hanging down, nails subulate. 4. *C. rosalia*, *Marikina* of Buffon and Audebert, *Silky Monkey*. Long-tailed, hair silky, and that on the head long, body yellow, contour of the face reddish, claws pointed. * 5. *C. iacchus*, *Ouistiti* of Buffon and Audebert, *Striated Monkey*. Ears spreading, and covered with long hairs, tail long, shaggy, and curved, nails of the fingers and toes subulate, and those of the thumbs round. 6. *C. morta*, *Monkie* of some of the French writers, a variety of Buffon's *Saïmiri*, *Naked-tailed Monkey*. Beardless, brown, with dusky muzzle, and long, naked, scaly tail.

* *C. Oedipus*. Body grey, and white underneath. This is a pretty little species, like a lion in miniature, has a musky odour, and a voice which has been compared to the chirping of a mouse. Plate CCCLIII. Fig. 2. It frequents the banks of the river Amazons, often walks with its long tail over its back, and is lively and sportive, but with difficulty conveyed beyond seas, being impatient of the rolling of a ship, and extremely susceptible of cold.

* *C. iacchus*. This is a very small species, seldom exceeding five inches in length, exclusively of the tail, which is about a foot long, and distinctly marked with alternate black and white rings. The body is ash-grey, the face naked and of a deep carnation tint; and there is a naked white spot above the nose. Mr. Parsons has described it in the 47th volume of the Philosophical Transactions, and Edwards has figured it in his gleanings. The latter naturalist informs us, that he had seen many individuals of this species, the largest of which scarcely weighed six ounces, and the smallest four ounces and a half. One of the most vigorous of those which he had occasion to examine, fed on various articles, as biscuit, fruit, vegetables, insects, &c. and once, when freed from his chain, he attacked and greedily devoured a gold fish. Small eels at first alarmed him by turning round his neck, but he soon prevailed over and ate them up. This monkey, from its diminutive size, can sometimes take up its lodging in the shell of a cocoanut. It is very active, restless, and cunning, and smells of musk. Though a native of the Brazils, it is capable of breeding in the warmer provinces of southern Europe.

5. Genus Cercopithecus, including *Guenon* and *Macaque* of some of the French zoologists. Head much flattened, facial angle sixty degrees, ten grinding teeth, two canine of moderate size, and four incisive in each jaw, cheek pouches naked, posteriors callous, tail long, not prehensile, and the arms proportioned to the legs. Indigenous to the old continent.

1. *C. nasalis*, *Simia nasilis*, Lin. *S. nasica*. Audeb. *Guenon à long nez*, or *nasique*, *Proboscis Monkey*. Nose very long, face black, beard short, drawn together, and acutely reflexed. 2. *C. comosus* of Latreille, *Guenon à camail*, Buff. *Full-bottom Monkey*. Body glossy black, hair on both sides of the face long, thick, waving, and of a yellowish hue, blended with black; tail white. 3. *C. Maurus*, *Guenon nègre*, *Negro-Monkey*. Long-tailed, blackish, with swarthy flesh-coloured face and breast, and blackish beard. 4. *C. nictitans*, *Guenon a nez proéminent*, Buff. *Hocheur*, Audeb. *White-nosed Monkey*. Long-tailed, beardless, black, freckled with white, thumbs very short, and no callosity behind. * 5. *C. petaurista*, *Guenon blanc nez*, Buff. and Audeb. *Vaulting Monkey*. Tailed, bearded, black, upper parts of the tail, and anterior parts of the legs, dark olive, the nose marked with a triangular white spot. * 6. *C. Nemæus*, *Douc*. Buff. and Audeb. *Cochin-China Monkey*. Bearded cheeks and long white tail. 7. *C. Entellus* of Dufresne, *Entelle* of the French writers, *Entellus Monkey*. Tail very long, colour of the hair approaching to straw-yellow. 8. *C. vetulus*, *Simia rubra*. Lin. *Patas*, Buff. *Red Monkey*. Tailed, bearded, cheeks hairy, crown, back, and tail blood-red, under parts pale-cinereous. 9. *C. Palatinus*, *Simia Diana*, Lin. *Diane*, Audeb. *Palatine*, Buff. *Diana*, or *Spotted Monkey*. Long-tailed, blackish, freckled with white, the hair of the forehead and beard growing in a pointed form, with a lunated band across the forehead. 10. *C. fuliginosus*, Geoffroy, *Simia Æthiops*, Lin. *Mangabey*, and *Mangabey à collier blanc*, of Buffon and Audebert, *Mangabey*, or *White eye-lid Monkey*. Long-tailed, beardless, with black face, white eye-lids, white frontal band, hair on the forehead upright. * 11. *C. Faunus*, *Malbrouck*, Buff. Beard hoary, pointed, tail bushy at the end. 12. *C. Atys*, *Atys Monkey*. Muzzle elongated, ears almost square, body of a dingy white, or straw colour, with the feet, hands, face, and ears, of a carnation tint. 13. *C. cæphus*, *Mouslac*, Buff. *Moustachio Monkey*. Long-tailed, blackish rusty above, whitish beneath, cheeks bearded, crown of the head yellowish, eye-lids red, and muzzle whitish. 14. *C. Ascanius*, *Ascanian Monkey*. Upper parts of the body of an olive-grey, the under dark-grey, face of a purplish-blue, nose flat and white, with black bands of hair from the mouth to the ears. 15. *C. Talapoin*, *Talapoin* of Buffon, &c. Long-tailed, olive-coloured, cheeks bearded, ears, nose, and soles of the feet, black. * 16. *C. Sabæus*, *Callitriche* of Buffon and Audebert, *Green Monkey*. Beardless, yellowish-green, face black, tail grey, haunches naked. * 17. *C. mona*, *Varied Monkey*, or *Mona*. Tailed, bearded, a prominent, whitish-grey, semilunar arch over the eye-brows. 18. *C. cynomolgus*, *Macaque*, Buff. *Hair-lipped Monkey*. Long-tailed, beardless, nostrils wide and bifid. 19. *C. aygula*, *Egret Monkey*. Like the preceding, but about one-third less in all its dimensions. 20. *C. Sinicus*, *Bonnet Chinois*, and *Guenon couronnée*, Buff. *Chinese Monkey*. Beardless, pale-brown, with the hair of the crown spreading round horizontally. 21. *C. Rhesus*, *Rhesian Monkey*. Hair on the head, neck, and ridge of the back, greenish-ashen, on the thighs and lumbar regions orange, on the belly whitish, and on the anterior parts of the four limbs grey; the fingers black, and the ears flesh-coloured. 22. *C. Nemestrinus*, *Maimon*, Buff. and Audeb. *Pig-tailed Baboon*. Olive-brown, with short naked tail.

**C. petaurista*. The length of the head and body is about thirteen, and that of the tail twenty inches. Professor Allamand, who was fortunate enough to keep one alive for some time, describes it as a most agile, gentle, and familiar animal, so rapid in its motions, that it seemed to fly rather than to leap, never retaining its resentment, and biting only in play. When still, its favourite attitude was to recline its head on one of its hind legs, which gave it an air of profound meditation. When presented with any thing to eat, it rolled it in its hands, before putting it into its mouth. It was averse to wetting its beard, and regularly wiped it on something dry, after drinking. It walked on four feet, except when it was desirous of examining an object, and then it approached it only on two.

* *C. Nemæus.* Among the various quadrupeds which excite our curiosity, or claim our attention, the Cochin-China Monkey is the most remarkable for the purity and harmony of colours in that robe with which nature has adorned him. His short flat face is of a reddish-brown, shaded on each side by a long yellow band; his forehead is black, and the rest of his head grey. A strong tinge of purplish brown surrounds his neck, in the manner of a collar. His arms, on the upper parts, are grey, but, from the elbows to the hands, they are perfectly white. His fingers are black; his back, belly, and sides grey, tinged with yellow; his loins and tail are white, his thighs sable, his knees and legs of a chesnut colour, and his feet black. These colours are all pure, never mingling with one another; and, as the shadings are not very lively, the assemblage is quite pleasing and harmonious. The generality of digitated quadrupeds, in Asia and Africa, have their posteriors naked; but those of this animal are covered with hair. An individual of the present species will sometimes measure four feet from the nose to the insertion of the tail. These monkeys inhabit Cochin-China and Madagascar. They frequently walk on their hind legs, and are very fond of beans, and liable to bezoardic concretions.

* *C. Faunus.* It measures about a foot and a half, from the extremity of the muzzle to the origin of the tail, which last is nearly of the same length. The individuals of this species are seldom perfectly reclaimed, and, it is alleged, never breed in confinement, even in their native country. When fruits and succulent plants fail them in the woods, they have recourse to insects, and sometimes migrate to the banks of rivers, or the sea-shore, to catch fish and crabs. By allowing the latter to lay hold of their tail, they carry them off abruptly, and devour them at leisure. They not only pluck the cocoa-nut from the tree, but continue to drink its included liquor, and to eat the kernel. They are frequently caught by making a small orifice in this nut, in which they get their paw entangled, and are taken by a person lying in wait, before they have extricated themselves. They are notorious pilferers of fruit and sugar-canes; and, when they attack the latter, in a predatory band, they station one of their number on a tree, who, in case of alarm, calls out *houp*, when all, dropping the canes which they held in their left hands, run off on three legs; if closely pursued, they also let fall the right handful of booty, and escape by climbing up the trees, and leaping from one to another, with astonishing nimbleness.

* *C. Sabæus.* This elegant species inhabits the Cape de Verd Islands, the Cape of Good Hope, the East Indies, and has greatly multiplied in the woods of Podor, on the banks of the Niger, in Mauritania, and in the territory of ancient Carthage. In these, its native regions, the animal is much more beautiful than after it has been imported into Europe, and its fine green has faded to olive. "I perceived them," says Adanson, "only by the branches which they broke from the tops of the trees, and which fell on me; for they were very silent, and so light and nimble in their gambols, that one could scarcely hear them. I stopped short, and killed one, two, and even three, before the others seemed to be alarmed: when most of them, however, felt themselves wounded, they began to take shelter, some concealing themselves behind the large branches, others coming to the ground, and the greater number darting from the top of one tree to that of another. During these little movements, I continued to fire on them, and killed twenty-three in less than an hour, and in the space of forty yards, without any of them uttering a single cry, although they had frequently collected in troops, grinding their teeth, and assuming a menacing aspect."—The apparent unconcern of these creatures, when Adanson first attacked them in those recesses, where they probably had never been before molested by any of the human race, perfectly accords with various other facts recorded by voyagers and travellers, and which warrant the assertion, that the inferior animals in general do not shun the approach of man, till they have learned from experience to dread his power.

* *C. mona.* The mona displays a great variety of colouring; the face being brown, the beard mixed with white, yellow, and a little black; the hair on the crown and neck yellow and black; that of the back rusty-brown and black; the belly and insides of the legs and thighs whitish; the outside of the legs and feet black; the tail dark-grey, with a small white spot at each side of its origin; and a black band from the eyes to the ears, and from the ears to the shoulders and arms.

Mona, *monina*, and *mone*, are Moorish and Provençal terms for a *long tailed monkey;* and its more popular designation of *varied monkey*, to which we find it is so well entitled, exactly corresponds with the *cebus* or *cephus* of the ancients, which Aristotle interprets, an ape or monkey with a long tail and diversified colours. Prudentius, in his enumeration of Egyptian idols, mentions, in the same verse, Isis, Serapis, and the long-tailed ape:

> "*Isis enim, Serapisque, et longa simia cauda.*"

Latreille ingeniously enough conjectures, that the species here alluded to is precisely that under consideration. Strabo attributes the worship of monkeys chiefly to the inhabitants of Memphis; and Diodorus Siculus assures us, that, in a certain country of Africa, (probably Egypt,) the natives held monkeys in such sacred veneration, that they carefully furnished tables with fruits and meats for their use; that it was a capital offence to kill one of them; that the names of children had usually some reference to these animals; and that three principal cities were assigned for their residence. In some quarters of the world, the same absurd superstition exists at the present times. The Portuguese, we are told, found in Ceylon a monkey's tooth, of such high importance in the eyes of the natives, that they valued it at 7000 ducats; and sanctuaries, we know, are allotted to the tribe, by the Brahmins, in different parts of Hindostan. Where monkeys are thus made the objects of worship, or even of superstitious regard, their numbers are very troublesome, as they frequently move about in large parties, and make free use of the houses. In Calicut, the inhabitants exclude them by means of latticed windows. In Amanadab, the capital of Guzerat, there are three hospitals for animals, where tame and sick monkeys, and even such as are in perfect health, but think proper to avail themselves of the charity, are fed and cherished. Twice a-week they spontaneously assemble in the streets, mount on the houses, and repose on the terraces, or flat roofs, during the heats. On these two days, the people always deposit on the roofs rice, millet, or fruit, otherwise their disappointed guests become so furious, that they break the tiles, and commit various other outrages. At Dherboy, according to Forbes, they are tolerated chiefly from views of humanity, and the prevailing belief in the metempsychosis. "The intrusion of the monkeys," says he, "I could have dispensed with. Their numbers were often formidable, and their depredations serious. I believe there were as many monkeys as human inhabitants in Dherboy; the roofs and upper parts of the houses seemed entirely appropriated to their accommodation. While the durbar was repairing, on my first arrival, I resided a short time in one of the public streets; the back of the house was separated by a narrow court from that of a principal Hindoo. It being the shady side, I generally retired, during the heat of the afternoon, to a veranda, and reposed on a sofa with my book. Small pieces of mortar and tiles frequently fell about me; to which, supposing them to be occasioned by an eddy of wind, I paid no attention; until one day, when I was so much annoyed by their repetition, accompanied by an uncommon noise, and a blow from a larger piece of tile than usual, that I arose to discover the cause; and, to my astonishment, saw the opposite roof covered with monkeys, employed in assaulting the white stranger, who had unwittingly offended by intruding so near their domain. Although my new situation invested me with considerable power, and made me the first man in the city, yet, as I knew I could neither make reprisals, nor expect quarter from the enemy, I judged it most prudent to abandon my lodging, and secure a retreat." The same writer informs us, that, on some occasions, these creatures are employed as the innocent agents of revenge. Previous to the commencement of the periodical rains, about the middle of June, it is customary to turn the tiles on the roofs of all the houses in the towns and villages, both of Europeans and natives. These tiles are not fixed with mortar, but are regularly laid one over the other; and, by being adjusted immediately before the setting in of the rains, they keep the roof dry during that period; after which, their being misplaced is of little consequence, in a climate where not a shower falls for eight months together. At this critical juncture, when the tiles have just been turned, and the first heavy rain is hourly expected, the injured person, who has secretly vowed vengeance against his adversary, repairs by night to his house, and contrives to strew on the roof a quantity of rice, or other grain. This is quickly discovered by the monkeys, which assemble in large bodies, to pick up such a favourite food; when, finding much of it fallen between the tiles, they make no ceremony of nearly unroofing the house, when no turners of tiles are procurable. Nor can any remedy be applied to prevent the torrents of rain from soaking through the cow-dung floors, and ruining the furniture and depositories of grain, which are generally formed of unbaked earth, dried, and rubbed over with cow-dung.

6. Genus CYNOCEPHALUS of Desmarest. Has the same characters as the preceding, except that it wants the tail. It includes only one species, namely,

* *C. inuus*, *Magot* of Buffon and Audebert. *Yellow*, or *Barbary ape*. Haunches naked, and head oblong. It is about three feet and a half high, and resembles the pigmy ape, but has the snout longer, the colour paler, and the nails rounded. It is a native of the forests of India, Arabia, and Africa. It particularly abounds in Barbary, and likewise occurs in the neighbourhood of Gibraltar. It is more capable than most of its congeners of enduring a European climate; for that which Buffon kept for several years was fond of the open air, and, even in winter, was frequently in a room without a fire. When food was brought to it, the creature always filled its cheek-pouches: and, when about to sleep, it sought to perch on an iron or wooden bar: but, though long in confinement, it never became perfectly tractable. This species, indeed, has been uniformly remarked for its fierce and unaccommodating spirit; and it is only by perseverance and dint of discipline that it is taught to dance, and perform its tricks for the amusement of the populace, being the sort most commonly exhibited at fairs and shows.

In the open plains of India, these animals sometimes assemble in large troops; and if they encounter any women going to market, attack them, and carry off their provisions. In the vicinity of their retreats, the people, for their own amusement, place five or six baskets full of rice, at forty or fifty yards asunder, along with a liberal supply of stout cudgels, and then retire to some hiding-place at no great distance; while the apes, observing the baskets deserted, descend from the trees, and cautiously advance, grinning for some time at one another, as if fearful to commence the contest. But the females, which are generally the boldest in approaching the store, being assailed by the males, both parties have recourse to the sticks, and mingle in a furious conflict, till the weakest are driven into the woods with broken heads and limbs, and the victors quietly devour the spoil.

7. Genus PONGO of Lacépède. Facial angle of thirty degrees, and furnished with cheek-pouches; tailless; four incisive, two very strong canine, and ten grinding teeth, in each jaw; a thyroidian sac; arms very disproportionately long.

1. *P. Bornensis*, *Pongo de Borneo*, and *Singe de Wurmb* of the French naturalists, *Wurmbian baboon*. Face of a dark tawny hue; body brown.

8. Genus PAPIO, Cuv. *Baboon*. Muzzle much elongated; facial angle about thirty degrees; nostrils very low, and separated by a very slender septum; four incisive, two very strong canine, and two grinding teeth, in each jaw; cheek-pouches, and thyroidian sacs; buttocks generally naked and callous; tail either of moderate length, or very short and thick; arms long; nails lengthened, and very strong, considerably resembling the claws of carnivorous animals. Resides in the hot countries of the old continent.

*1 *P. sphinx*, *le grand papion*, or *Babouin á longues jambes* of the French; *baboon*, *common*, *mottled*, or *great baboon*. Face black; body of a tawny flesh colour; nails pointed; haunches naked. 2. *P. porcarius*, *le petit papion*, Fr. *Hog-faced baboon*. Short tailed, brown, covered behind; face naked, and shaped somewhat like that of a hog; nails pointed. 3. *P. silenus*, *Wanderoo*, or *lion-tailed baboon*. Beard long and black; body black. * 4. *P. hamadryas*, *Singe de moco*, *&c. Tartarian monkey*, *dog-faced*, or *grey baboon*. Cinereous, ears hairy; nails somewhat acute: haunches reddish. 5. *P. mormon*, *mandrill*, Buff. *rib-nose baboon*, or *mandrill*. Beard thin; cheeks blue and striated; callosities naked.

* *P. sphinx.* From three to four feet high. Linné, misled probably by Gesner's figure, has given whiskers to this species. It has pouches in the cheeks, and large red callosities behind. Its tail is crooked and thick, and about seven or eight inches long; the snout very thick and protruded; and the upper parts of the body very strong and muscular. The hair has a mottled appearance, when narrowly inspected; and the eyes, which are deeply seated, are hazel.

The common baboons, whose aspect is not less grotesque than formidable, occur in the hottest parts of Africa, and also in the island of Borneo, and are remarked for the wildness and lubricity of their manners. When collected in large troops, they not only pillage orchards, according to a systematic plan, but strip houses of all sorts of provisions, when the people are occupied with the rice-harvest. One of them has been known to put eight eggs into his cheek-pouches at a time; and then taking them out one by one, break them at the end, and very deliberately swallow them. Their great strength, and the sharpness of their claws, render them formidable to dogs, which overcome them with difficulty, unless excess of eating, as sometimes happens, makes them heavy and sluggish. In confinement, they are savage and ill-natured, frequently grinding their teeth, and exhibiting every symptom of fury. In our temperate climates they do not propagate; and, even in hot latitudes, the female usually brings forth only one at a time, which she carries in her arms, and allows to cling to her back.

When taken very young, and fed with the milk of sheep and goats, the baboon may be tamed to a considerable degree, and taught, as at the Cape of Good Hope, to guard the house, like a watch-dog; a duty which it performs with great punctuality.

* *P. hamadryas.* About five feet high; the face very prominent; the nose smooth and red; the hair freckled with minute dusky specks, and flowing over the shoulders, in length and elegance like a waving mantle. It has the tail of a monkey, and the habits of a baboon. In the hotter regions of Asia and Africa, herds of this species often occasion great damage to the coffee plantations.

The *ursine baboon* is a reputed variety of this species, and is distinguished by long upright hairs on the crown of the head. It is extremely common in the mountainous districts about the Cape of Good Hope, and seldom descends into the plains, except for the purpose of plundering gardens. When these animals congregate on the tops of the rocks, it is not always safe to pass near them; for they not only roll down stones of considerable size, but throw them from their hands; and they are seldom driven away, except by fire-arms. When they observe any single person resting and regaling himself in the fields, they will sometimes cunningly steal up behind, snatch off whatever they can lay hold on, then, running to a little distance, will turn round, sit erect, and, with the most arch grimaces, devour it before the owner's face. They frequently hold it out in their paws, as if to offer it back again, and with such ludicrous gesticulations, that, although the plundered person probably loses his dinner, he seldom can refrain from laughing. This, among various other anecdotes which might be mentioned, seems to prove, that the monkey tribes are not wholly destitute of a sense of humour, though usually of a satirical or hurtful kind. The ursine baboons are sometimes rendered docile by confinement and discipline; but seldom forget to revenge an injury, whenever it is in their power. If irritated by any person, they attempt to lay hold of his ears, and will sometimes bite one of them off as close as if it had been cut with a razor. So predominant in their conduct is the influence of the imitative disposition, that we should be careful in their presence not to set any example which we do not wish them to follow. Mr. Boodle, a gentleman of considerable property, kept one of them, which copied his actions with more ingenuity than discretion. A large box of cathartic pills had, it seems, been sent by the apothecary, with directions for Mr. B. to take two of them occasionally. It so happened that *Jack* perceived his master take the first dose, and put the box on the mantle-peice; and no sooner was the creature left alone, than he took it down, but not exactly understanding the label, swallowed pill after pill, till no more remained. Then, deliberately replacing the box on the mantle-piece, he went down stairs, and seated himself by the kitchen fire. Here, however, he did not tarry long; for the strength of the physic, aided by the heat, excited such a commotion, that he ran somewhat abruptly to the garden, and took his station on a tree, where he remained, wailing piteously, till order was restored to the system.

9. Genus ALOUATTA. Head pyramidal; facial angle about 30 degrees; nostrils lateral, and separated by a thick cartilage; four incisive, two canine, and twelve grinding-teeth in each jaw; the lower jaw much elevated; no cheek-pouches; tail very long and prehensile; posteriors hairy; legs nearly of the same length with the arms; an osseous tympanum formed by the body of the hyoidian bone, and placed in the interval of the branches of the lower jaw. Resident in South America.

* 1. *A. seniculus*, *Alouatte roux*, and *Hurleur*, Buff. and Audeb. *Royal monkey*, *howler*, or *old man of the woods*. Tailed, bearded, and red. * 2. *A. Belzeebul*, *Ouarine*, Buff. Audeb. *Howling baboon*, or *Preacher monkey*. Bearded, black, the feet and tip of the tail brown.

* *A. seniculus.* In manners and dispositions this species nearly resembles the following, of which it has sometimes been considered only as a variety. It is, however, rare in Brazil, and very common in Cayenne; whereas the other is very common in Brazil, and not found in Guiana. The howlers inhabit the moist forests in the neighbourhood of waters or marshes, and are usually found in the wooded islets of large flooded savannahs. They move in small numbers, often in pairs, and sometimes singly. It is generally in the mornings and evenings, that they send forth their horrible rattling scream, which they also repeat in the course of the day, and sometimes during the night. So loud and varied is their utterance, that a stranger is apt to ascribe it to all the savage tenants of the forest, and is surprised to find that it is produced by only two or three, and, sometimes, by a solitary individual of this species. None of them long survive captivity.

* *A. Belzeebul.* The full grown male is about forty-four inches long, of which the tail forms nearly one-half; and the female is shorter by three or four inches. A dark and thick beard, about three inches long, hangs from the chin, and gives the animal the mock air of a capuchin friar.

These baboons are so wild and mischievous, as not easily to be subdued or tamed, biting severely, and exciting apprehension by their hideous aspect and singular clamour, which resembles the noise of a drum, and may be heard at the distance of two or three miles. They usually keep together in parties of twenty or thirty, rambling over the tops of the woods, leaping from tree to tree, and never falling to the ground, though they frequently throw themselves headlong in the air. Every morning and evening, they congregate in vast numbers, and make the air resound with a tremenduous noise, which has been compared to the rumbling of many carts, with ungreased wheels. One of them will sometimes mount on an elevated branch, and the rest seat themselves beneath. The president seems to commence a harangue, and sets up a howl so loud and sharp, as to be heard at a great distance; he then gives a signal with his paw, when the whole assembly join in frightful chorus. On another signal, they are again silent, and allow the orator to finish his address.

"When we approached," says Oxmelin, (who attended the hunting of these animals,) "they all flocked together, uttered loud and fearful cries, and assailed us with dried branches, which they broke off from the trees. I likewise observed, that they never abandoned one another."—"If they are not shot dead at once, they can never be taken; for, even when mortally wounded, they remain fixed to the trees, where they often die, and do not drop down till corrupted. More than four days after death, I have seen them firmly fixed to the trees; and thirteen or sixteen of them are frequently shot, before three or four can be obtained. What is singular, is, that as soon as one is wounded, the rest collect about him, and put their fingers into the wound, as if they meant to probe it; and, when much blood is discharged, some of them keep the orifice shut, while others make a mash of leaves, and dexterously stop it up. This process I have often observed with much admiration." Did not the writer assert the last-mentioned circumstance in this positive manner, we might be inclined to question his accuracy. We should recollect, however, that we are treating of an imitative race of quadrupeds, some of which are, perhaps, capable of copying the details of a surgical proceeding, which is by no means very complex or delicate. The females produce one, or, at most, two, at a birth, and carry and suckle their cubs, as negro women do their children.

The *second family* of this order has been denominated *Lemures*, or *Makis*. Its characters are, body slender; muzzle elongated; orbits much approximated, and separated from the temporal fossæ; facial angle at least thirty degrees; incisive teeth varying in number, from two to six, in each jaw, according to the genus; the crown of the grinding teeth tuberculated, or furnished with points; the foremost of the grinders rather longer and sharper than the rest; the occipital aperture much raised; usually five toes on each limb; nails of the hands flat, and much resembling those of man; nails of the feet like those of the hands, with the exception of the first, or of the two which immediately follow the great toe, which are lengthened and hooked; posterior tarsi often very long; tail, in some, wanting; in others, long, hairy, and not prehensile; body always covered with hair; no callosities behind; two or four pectoral mammæ; no vermiform processes in the cæcum, as in man, and some of the apes. Indigenous to the old continent.

Although the quadrupeds which compose these families were formerly classed with the preceding, they present more material differences than the mere structure or arrangement of the teeth. While their hand-like paws and manner of living assimilate them to the monkeys, the form of their head more resembles that of the fox, their hinder are longer than their fore limbs, so that they walk with an awkward gait, but are enabled to climb trees, and to leap among the branches with wonderful ease and celerity. With the exception of a single species, none of them approach in appearance to the human figure, though their arms, hands, body, and feet, if separately examined, are somewhat similar to the corresponding parts of our own frame. They feed on fruits, vegetables, or insects, and are said to be devoid of the petulant and teasing propensities of many of the ape tribes, and to manifest a peculiar gentleness of disposition: but as their usual residence is in sequestered retreats of the forest, in the warmer regions of the globe, we are in possession of very scanty and imperfect information relative to their instincts and habits in a state of wildness.

1. Genus Maki, Desmarest; *Lemur*, Lin. Muzzle much elongated; four superior incisive teeth; six inferior, inclined forward; grinders with blunted tubercles; ears short, and concealed in the hair; posterior tarsi of moderate length; tail very long.

1. *M. mococo*, Desmar.; *Lemur catta*, Lin.; *Ring-tailed Lemur*. Tail with white and black annulations. 2. *M. mongous*, Desmar. *Lemur mongoz*, Lin. *Woolly mongoz*. Of a brown-grey colour. 3. *M. vari*, Desmar. *Lemur macaco*, Lin. *Vari*, *black*, or *ruffled Lemur* or *Macaco*. Black, with the neck bearded, like a ruff. 4. *M. rufus Lemur. Rufus*, Audeb. *Rufous Lemur*. Rufous, with a black line proceeding from the front to the crown of the head, and the tip of the tail brown. 5. *M. albifrons*, *Lemur albifrons*, Geoffr. and Audeb. *white-faced Lemur*. Head of a dull white. 6. *M. griseus*, *Lemur griseus*, Geoffr. and Audeb. *L. murinus*, *Murine*, or *Little Lemur*. Tail long and rusty; body ash-coloured. 7. *M. pusillus*, *Lemur pusillus*, Audeb. *Rat de Madagascar*, Buff. *Dwarf Lemur*. Muzzle less projecting than in its congeners; body grey; eyes large, and encircled with brown.

2. Genus Indri, Geoff. *Lemur*, Lin. Muzzle much prolonged; four incisive teeth in each jaw, with those of the lower projecting; grinders with blunted tubercles; the other characters corresponding with those of *Maki*.

* 1. *I. brevicaudatus*, Geoff. *Lemur Indri*, Lin. *Indri*, or *Indri Macaco*. Black above, greyish beneath; the countenance and space round the rump whitish. 2. *I. longicaudatus*, Geoff. *Lemur laniger*, Lin. *Flocky Lemur*. Long-tailed, pale-tawny; white beneath; tail rusty.

* *I. brevicaudatus*. The hair or fur is thick and silky, and, in some parts, of a curled or crisped appearance; three feet and a half high, but very gentle and docile, so that, when taken young, it is trained by the natives of Madagascar to hunt like a dog. This species bears no indistinct resemblance to the human form. Its eyes are white and lively, and its generative organs have a similar conformation with those of monkeys. Its voice has been compared to that of a crying infant.

3. Genus Loris, Desmar. Lemur, Lin. Head rounded, muzzle short, and abruptly turned up; four incisive teeth in each jaw, those of the lower projecting; grinders with pointed tubercles; eyes very open; ears of moderate size; nostrils lateral; only the rudiment of a tail; four pectoral mammæ.

1. *L. gracilis*, *Lemur gracilis*, Geoff. *slender lemur.* Body covered with a fine and somewhat rufous hair; ears rounded, and furnished internally with three flaps, or earlets. * 2. *L. tardigradus*, *Lemur tardigradus*, Lin. *slow lemur.* (Plate CCCLIII. Fig. 5.) Of a light-brown hue, with a brownish line on the back. The eyes, which are very prominent, are surrounded by a dark-brown circle, with a white longitudinal line between them; the hands and feet are naked, and the nails rounded. It is about the size of a small cat, or squirrel, and is very long in proportion to its thickness, being furnished with *nine* lumbar vertebæ, whereas other animals have only five, six, or seven. Its head is quite spherical, and the muzzle placed on it almost perpendicularly. It it a native of Ceylon, Bengal, and various parts of the East Indies. Its slow-paced motion has been much exaggerated. The fact seems to be, that it is a nocturnal animal, addicted to sleep in the day-time, and when molested in that state, naturally appears sluggish; but it is very active during the night. The individual which Vosmaer possessed slept all day, and awoke about half-past eight o'clock in the evening. It was kept in a cage formed of iron wires, and it constantly slept, seated on its rump, close to the wires, with its head bent forward between the two fore feet, which were placed over its belly. Its motion, when it was roused in the day-time, was extremely slow, and always the same, drawing itself on from bar to bar, taking hold of the upper part of one bar with its fore feet, and not quitting it till it had slowly grasped another with one of its hands. When it crept on the floor, it dragged one foot after the other as if paralyzed, raising its body very little from the ground. A stick passed through the wires did not make it let go its hold; but, if pushed too rudely, it bit the stick, and had recourse to no other sort of defence. Towards evening, it gradually emerged from its slumber, when its first care was to regale itself with food. Its common diet was rice boiled very thick; and it would willingly eat of dry bread and biscuit, but would not touch them if dipped in water. When this last mentioned liquid was presented, it contented itself with smelling it, but refused to drink. It was particularly fond of eggs, killed a sparrow with a bite, greedily devoured it, afterwards eat a chaffinch, and then slept the remainder of the day. When forcibly stirred during the day it was angry, and bit the stick with which it was teased, but with a very tardy motion, and the reiterated cry of *ai*, prolonging this diphthong into a plaintive, languid, and tremulous sound, like the American sloths, among which, indeed, M. Vosmaer was inclined to class it. To these quadrupeds, however, it bears no other affinity; nor can it be placed in the same genus. It likewise deserves to be remarked, that, sluggish and inert as it certainly is, it is not so torpid and inactive in its native climate, as when brought into the colder regions of Europe. A most interesting account of one of these little creatures, from the pleasing pen of the late Sir William Jones, is published in the fourth volume of the Asiatic researches; but it is too long for insertion in this place.

4. Genus GALAGO, Geoff. Head rounded; muzzle short; two upper incisive teeth separate; six lower grinders with sharp tubercles; nostrils lateral; ears naked; fore paws short; posterior tarsi elongated; the second toe of the hind foot the shortest of all; tail longer than the body, and furnished with hair; scrotum very large.

1. *G. Senegalensis*, Geoff. and Audeb. *Senegal lemur.* Ears large, about the size of the domestic cat. 2. *G. minutus*. *Lemur minutus*, Lin. *Little lemur.* Ears small, about the size of a mouse.

5. Genus TARSIUS. Geoff. TARSIER of the French. Head rounded; muzzle little elongated; four incisive teeth in the upper jaw, only two in the lower; several canine shorter than the incisive; grinders with sharp tubercles; posterior tarsi very long; tail long and bushy; ears large and naked.

1. *T. Daubentonii*, Geoff. and Audeb. *Lemur tarsius*, Pallas; *Didelphis macrotarsus*, Lin *Daubentonian tarsier.* Tail slender, naked, but hairy at the tip: heels of the hind feet long and naked; thumb nail flat. 2. *T Pallasii*, *Lemur spectrum*, Pallas. *Pallasian tarsier.* Incisive teeth obtuse. 3. *T. Fischerii*, Desmar. *Fischerian tarsier.* Light brown on the back, grey white under the belly; ears large, and externally covered with very fine hairs.

ORDER III. CARNIVORA.

This designation includes the *Feræ*, and some of the *Primates* of Linnè. They have been distributed by Desmarest into the ensuing *sub-orders* and *families*.

1. SUB-ORDER. CHEIROPTERA.

Characters. The skin of the sides extending in the form of membraneous folds, to the extremities of the four limbs; frequently a similar membrane between the two hind legs, partially or wholly, including the tail, when it exists; the fingers of the hands generally very long, and united by a membrane; the grinding teeth in the greater number furnished with pointed tubercles; the generative organs in the male externally visible; penis propendent; two pectoral mammæ; eyes generally small; orbitary and temporal fossæ united; perfect clavicles; the cubitus and radius united by a solid joint.

The *first family* of this *sub-order* has been denominated GALIOPITHECI. They are distinguished by having the fingers longer than the toes; by their hooked and sharp claws; by the hairy membranes which unite the neck to the arms, the arms to the legs, and the legs to one another; and by the papillæ which cover the tongue.

The only genus is GALEOPITHECUS, LEMUR, Lin. The animals belonging to it have two superior incisive teeth separated, six inferior, of which the four intermediate are longitudinally furrowed, and formed like a comb on their upper surface, the canine teeth wanting, the grinders with blunted tubercles; short fingers, covered by a membrane to the base of the nail; and the cæcum of very large capacity.

* 1. *Galeopithecus rufus*, Audeb. *Lemur volans*, Lin. *Flying lemur*, or *colugo*. Of a lively cinnamon hue on the back, and paler under the belly. 2. *G. variegatus*, Cuv. *Variegated colugo.* Of a dark colour, varied with different shades and points.

* *G. rufus*. (Plate CCCLIII. Fig 6.) This species measures about three feet in length, including the tail, and nearly as much in breadth, when expanded. It runs along the ground, and climbs up trees like a cat, its wing-like membrane sustaining its body in the air. It is gregarious; lives on the fruits of trees, and flies in the twilight like the bats. It is a native of Guzerat,

and of the Philippine, Molucca, and Pelew islands. In the last mentioned its flesh is held in the highest estimation.

The *second family* comprises the Vespertiliones, or Bats.

Characters. The skin of the body laterally prolonged to the extremities of the toes; the toes or fingers of the fore limbs much longer than those of the hinder, united by broad membranes, usually without claws; the thumb separated, but always very short in proportion to the other toes, except in the genus *Pteropus*, and always armed with a strong and very sharp claw; the toes of the hind feet united, very short, and provided with very strong nails; cutting teeth sometimes wanting in one of the jaws, or varying in number from two to six; canine teeth for the most part very strong; grinders, in most instances, with sharp protuberances; wing-like membrane naked; either a tail, or the rudiments of one; ears almost always large, in proportion to the dimensions of the animal; cæcum wanting; sternum with a bony *crista.*

Animals of this family were the cause of evident perplexity to the elder naturalists, some of whom classed them among birds, under the very unphilosophical denomination of *Aves non aves*. Nor was it till towards the close of the seventeenth century, that they were decidedly ascertained to occupy a station among the viviparous quadrupeds. We may affect to treat with ridicule the accuracy of a system, which comprises bats in the same order with man; but we cannot deny, that these animals agree with the other genera of *Primates* in having two pectoral teats, the thumb separated from the fingers, in the disposition of their teeth, and in their monogamous habits. With the feathered tribe they can claim no alliance or kindred; for they do not even resemble them in any respect, except that of being capable of moving about in the air. They have neither feathers nor beak; but their body is covered with hair, and their mouth is furnished with teeth. Instead, too, of producing eggs like birds, they bring into the world living young, which, in the manner of all the other *mammalia*, they suckle by means of teats. What is commonly called their *wings*, consists only of an extremely thin, light, and delicately formed membrane, which extends from one shoulder entirely round the body to the other, connecting the fore and hind legs, and capable, from its tenuity and flexibility, of being contracted at pleasure into innumerable folds, so as to occupy little room when the animal is at rest, and of being stretched to a wide extent for occasional flight. Their eyes are deeply seated in the head, and so small as to be scarcely visible; nor does it appear that they are of any essential use in directing their course; for it is a very extraordinary fact, that privation of sight does not prevent them from moving in the air, and from avoiding obstacles, to all appearance, as readily as when they retain the powers of vision. The ingenious Spallanzani was led to this singular discovery, in the course of some experiments which he happened to institute on nocturnal birds. When several of these were let loose in a darkened chamber, he perceived that the bats flew about in it without any impediment, and neither rushed against any thing, nor touched the walls. At first he supposed that they were guided by some glimpse of light, which had escaped his observation; and, with a view to satisfy himself in this particular, he blindfolded them with a small and very close hood. They then ceased to fly, not, however, from want of light, but from the constraint to which they were subjected. He had, therefore, recourse to pasting up their eyes, first with gum or size, and afterwards with round bits of leather; in both which cases they flew about as if they had had the free use of sight. At last he blinded them entirely, either by burning the cornea with a red hot wire, or by extracting the pupil with small pincers, and even scooping out the whole organ. Although the poor creatures seemed to suffer very much from these cruel operations, yet, when they were compelled to make use of their flying membrane, either during the day or night, and in an apartment completely darkened, they flew perfectly well, and with great caution, towards the walls, that they might suspend themselves when they wished to rest, avoiding interruptions of every kind, and gliding from one room to another, backward and forward, through a common door, without touching the frame. They appeared, in short, to be as bold and lively in their flight, as any individuals of the species which enjoy perfect vision. These experiments were repeated, with the same results, by Vasalli at Turin, Rossi at Pisa, Spadoni at Bologna, and Jurine at Geneva. The last mentioned gentleman suspended in an apartment several willow twigs three feet in length, at the distance of six inches from one another, and let loose two bats, which passed and repassed between them without touching them. After their eyes were cut out, they still directed their course to the same intervals; and, when these were barred up, they made choice of others, through which they passed repeatedly, always clearing the twig without contact, and for that purpose passing obliquely. None of the theories which have been proposed to account for the remarkable anomaly just stated, appear to be satisfactory. We shall, therefore, only take leave to remark, that the expanded membrane of the bat presents a very considerable surface to the air; that numerous and minutely ramified nerves are distributed through it, forming a *plexus*, or network, of wonderful fineness; and that the air, when struck by this very sensible organ, may impress such sensations of heat, cold, mobility, or resistance, as may indicate to the animal the presence of objects in the direct path of its progress.

Bats usually breed about mid-summer. The young, which are generally two, are at first perfectly naked, and have been compared by some of the old writers to human infants. They are suckled by the dam, and, from the moment they come into the world, they cling to her body with such tenacity, that they are not to be shaken off, even by her flights in quest of food. During their most active season, they conceal themselves in the day-time in holes of caverns, or old buildings, whence, on the approach of evening, they sally out in search of insects, particularly gnats, ephemerous flies, and various kinds of moths, which then swarm in the air. To enable them to catch their prey with the greater facility, their mouths are so wide as to extend almost from ear to ear. It has been observed, that they more easily endure hunger than cold, as they can pass several days without eating; and yet they are a carnivorous race, and will devour raw or dressed meat, whether fresh or tainted, when it happens to be within their reach. On the approach of the cold evenings of autumn, most of the species retire to their deepest recesses, and are no longer to be seen abroad, but fall into their long brumal slumber, which is technically termed *hybernation;* a state of torpor, to which several species of animals are incident at the very period when their food becomes defective, or wholly disappears. Hybernating bats are often found suspended in large clusters, the better to defend themselves against the chilling effects of the frost. Their long lethargy, *simillima mortis imago,* cannot be very remote from actual dissolution; for some of the most important animal functions are at least so far suspended as to be scarcely perceptible. The action of the heart and arteries, for example, becomes so languid, that the pulse can scarcely be felt; and it is very doubtful if respiration be at all carried on. The circulation of the blood is not discernible in the smaller vessels; but, when the animal is revived by warmth, it again becomes visible by the microscope. During hybernation, the animal's temperature falls greatly below the ordinary standard, while digestion, and the visible excretions, are arrested. It is presumed, however, that the adipose matter in the follicles of the cellular membrane is gradually taken up by the absorbents into the languid circulation; for the creatures enter into their dormant state very fat, and revive much emaciated. On the whole, they fare better during a severe than a mild winter; for warm weather not only awakens them, but re-excites their digestive powers at a season when the requisite supply of food is not attainable. Some have been observed to come forth at the temperature of 42° of Fahrenheit's thermometer, and others only at that of 48°. Such of them as have been roused by irritation, or the sudden application of heat, have seldom survived the third day; but then it is stated that the weather became colder. In this dormant state, the lingering remains of vitality may be ascertained by the touch, or the approach of a lighted candle, from either of which the animal will be perceived to shrink. A moderate and equable heat, such as that of the human hand or bosom, is most likely to revive them, as well as other torpid animals, which are often killed by being placed too near the fire.

To these observations on this family of quadrupeds, we have to add, that the sable and unusual aspect of most of the species, their flitting about in dubious light, their carnivorous propensities, and their dark and solitary dwellings, have naturally conspired to excite emotions of gloom and repulsion, especially in the minds of the ignorant and superstitious. Hence the ancients consecrated the bat to Proserpine, and ranked it among the tenants of the infernal regions, while poets and painters lend the leathern and ominous wing to their malevolent spirits. Homer, who is alike skilful and happy in his comparisons, has adopted these animals in the mass, to impart more graphic effect to the shrieks of his ghosts in the lower world :—

> "As in the cavern of some rifted den,
> Where flock nocturnal bats and birds obscene,
> Cluster'd they hang, till, at some sudden shock,
> They move, and murmurs run through all the rock:
> So cow'ring fleet the sable heaps of ghosts,
> And such a stream filled all the dismal coasts."

1. Genus Pteropus, Erxleben, &c. Rousette, Cuv. and Geoff. Vespertilio, Lin. Muzzle short; four sharp cutting-teeth in both jaws, canine teeth strong and separated, grinders with blunt protuberances; thumb very long and vigorous, though almost destitute of muscles; index armed with a weak nail; tail wanting; the triangular rudiments of a membrane between the hind legs; no membranous crests on the nose; the tongue beset with horny papillæ, directed backwards; large eyes; and no external ears. Resident in the warm and eastern countries of the old continent.

1. *P. fuscus*, Brisson and Geoff. *Rougette*, Desmar. *Brown pteropus.* Brown, with a semi-collar of bright red, blended with orange. 2. * *P. vampyrus*, Erxleb. *Vespertilio vampyrus*, Lin. *Ternate*, or *vampyre bat*, or *great bat of Madagascar.* Tailless; nose plain; membrane divided between the thighs. 3. *P. Stramineus*, Geoff. *Yellow pteropus.* Of a straw-yellow hue. 4. *P. pusillus*, Geoff. *Dwarf Pteropus.* Has the same character as *vampyrus*, except that it is much smaller, and of an olive colour. 5. *P. Ruber*, Geoff. *Red-throated Pteropus.* Like the brown species, except that it has a red throat. 6. *P. cephalotes*, Geoff. *Vespertilio cephalotes*, Lin. *Molucca Bat.* Yellowish grey; head large; nostrils spiral; ears small and valveless.

* *P. Vampyrus.* (Plate CCCLIII. Fig. 7.) From five inches to a foot in length, and the extent of the expanded membrane from two to four, or even six feet. Sir Hans Sloane possessed a specimen from Sumatra, whose out-stretched membrane measured seven feet. The tongue is pointed, and terminated with sharp prickles. Its prevailing colour is black, or dark-red, and sometimes brownish-black. The structure of the stomach is somewhat singular. The œsophagus swells out before it enters the general cavity; and the dilatation appears to belong to the stomach, as there is no contraction or distinct orifice beyond it. After the stomach has extended the same length on the left of the œsophagus as on the right, it is turned back on itself as far as the entrance of the œsophagus, then makes another turn, and ends in the pylorus by a very small valvular opening, which, when in a contracted state, scarcely gives a passage to the air. No part of this viscus is lined with a cuticle.

This species is a native of the west of Africa, the south of Asia, and the islands of the Indian Ocean, and South Seas. It is very common in Madagascar, the Isle of Bourbon, the Philippines, &c. and is more frequent in the islands of the Indian archipelago than on the adjacent continent. At the Friendly Islands these bats are very gregarious; and some of them are seen flying about during every hour of the day. Dr. Forster, found at least five hundred of them hanging in various attitudes, to a single tree; some of them depending by the fore-feet, and some by the hind. Multitudes of them may often be observed darkening the air, laying waste the ripe produce of the country, devouring, indiscriminately, fruits, flowers, and insects, and sipping the juice of the palm trees, of which they are so fond as sometimes to drink to exces, and fall senseless to the ground. They are easily taken, by placing within their reach vessels filled with palm wine, or other fermented liquors. During the night they make a hideous din in the forest, and may sometimes be heard at the distance of two miles. The Moors and Malays reckon the flesh of this species excellent food, comparing it to rabbit or partridge; and the French in the Isle of Bourbon put it into their soups, to give them a relish. According to Commerson, its flavour very nearly approaches to that of the hare; and the flesh is of the same dark hue. It has the trivial name of *vampyre*, from an imaginary monster which was supposed to suck the blood of persons asleep. In fact, like the spectre bat, it has the reputation of sucking the blood of those who lie with their extremities exposed, and even in some instances, of bleeding them to death. The animal is said to be such a dexterous phlebotomist, as to insinuate its aculeated tongue, quite insensibly, into a vein, and then to suck till satiated, fanning all the while with its wing, and thus lulling its victim into deeper slumbers.

The dismal aspect of the vampyre bat, and its foul habits, are supposed to have suggested to the ancients the fable of the Harpies. The Greek and Roman writers, however, appear to have had very vague and imperfect notions of those larger species. Herodotus, indeed, alludes to them, and mentions that the gatherers of cassia, in the marshy grounds of Asia, were obliged to protect themselves against their dangerous bites; and it is not a little amusing to remark, that Pliny, who has gravely recorded so many apocryphal and marvellous anecdotes, here challenges the veracity of the Greek historian. Strabo makes mention, though in general terms, of very large and edible bats in Mesopotamia.

2. Genus VESPERTILIO, Geoff. Including the greater number of *bats*. Two or four cutting teeth in the upper jaw, those in the middle separated; six in the lower jaw, with toothed edges; canine not remarkably strong, and disposed at intervals, so as to admit the cutting teeth; the grinders with sharp tubercles; thumb very short; no nail on the index; the tail quite included in the membrane which unites the legs; no membraneous crest on the nose; eyes small; an outer covering or flap for the ears; tongue smooth; hair short and smooth. Resident in the warm and temperate climates of the two continents.

1. * *V. minimus*, Lin. &c. *Common* or *short-eared bat*, *Rere-mouse*, or *Ranar mouse*. Tailed; mouth and nose plain; ears less than the head. 2. *V. Noctula*, Lin. *Great*, or *Noctule Bat*. Tailed; nose and mouth plain; ears oval, with a cover. 3. *V. lasiurus*, Lin. *Rough-tailed Bat*. Lips tumid; tail broad and hairy. 4. *V. auritus*, Lin. *Eared*, *large-eared*, or *long-eared Bat*. Tailed; nose and mouth plain; external ears double, and larger than the head. 5. *V. pipistrellus*, Lin. *Pipistrelle Bat*. Tailed; brownish-black; forehead convex; ears ovate, and thickest at the edges. 6. *V. barbastellus*, Lin. *Barbastelle Bat*. Tailed; cheeks full or turgid, and bearded; ears large, and angulated at the lower part. 7. *V. serotinus*, Lin. *Serotine Bat*. Yellowish, with short emarginate ears. 8. *V. nigrita*, Lin. *Senegal Bat*. Yellowish-brown, with the fore-part of the head, the feet, and tail, black. 9. *V. Pictus*, Lin. *Striped Bat*. Nose simple; ears funnel-shaped, and appendiculated. 10. *V. Novæboracensis*, Lin. *New York Bat*. Tail long; rusty-coloured; nose short and sharp; ears short and round, with a white spot at the base of each wing. 11. *V. Borbonicus*, Geoff. *Isle of Bourbon Bat*. 12. *V. nasutus*, Lin. *Greater Serotine Bat of Guiana*. Of a chesnut hue, with long sloping nose, and long upright rounded ears.

* *V. murinus*. About the size of a mouse; weighs from 120 to 160 grains; breadth of the expanded membrane about nine inches. This species is of such common occurrence in most of the countries of Europe, that a more detailed description would be superfluous. In this island, either it or the large-eared kind may be seen, almost every fine evening of summer and autumn, towards the approach of night, principally frequenting the sides of woods, glades, and shady walks, or skimming along the surface of rivers or standing waters. Being less readily affected by cold than some of its congeners, it has sometimes been observed fluttering about in the early part of the month of December. The female, which usually produces two young at a time, makes no nest for them, but is contented with the first convenient hole that occurs, and there, sticking herself by her hooked claws against the sides of her apartment, she permits her young to hang at the nipple, and, in this manner, to continue for the first or second day. When, after some time, the dam begins to be hungry, and finds it necessary to stir about, she takes her little ones, and sticks them to the wall, in the manner that she herself hangs; and there they immoveably cling, and await her return.

Bats are susceptible of a certain degree of domestication. The late ingenious and entertaining Mr. White, of Selborne, informs us, that he was much amused with the sight of a tame one; and both his observations, and those of Mr. Bingley, sufficiently confute the vulgar error, that these creatures, when on a flat surface, are incapable of rising into the air, and must crawl to some elevation, before they can unfold their membrane for flight.

"If we consider the bat," says Goldsmith, "as it is seen in our own country, we shall find it a harmless, inoffensive creature. It is true, that it now and then steals into a larder, and, like a mouse, commits its petty thefts on the fattest parts of the bacon. But this happens seldom; the general tenor of its industry is employed in pursuing insects that are much more noxious to us than itself can possibly be; while its evening flight, and its unsteady wabbling motion, amuse the imagination, and add one figure more to the pleasing group of animated nature."

3. Genus NYCTERUS, Geoff. Four bi-lobated cutting teeth in the upper jaw, without an interval between those in the middle; six, also bi-lobated, in the under jaw; two canine, not remarkably strong, and eight grinders, with sharp protuberances in each jaw; hair very long; no membraneous crest on the nose. Resident in the torrid zone. The genus contains only one species, namely,

1. *N. hispidus*, *V. hispidus*, Lin. *Campagnol volant*, Daubenton. *Bearded bat*. Hairy, with channelled nostrils, and long narrow ears.

4. Genus RHINOLOPHUS, Geoff. and Cuv. *Vespertilio*, Lin. Two very small bi-lobated cutting teeth in the upper jaw; four tri-lobated in the under jaw; canine very strong, separated by a sufficient space at their base for the addmission of the cutting teeth; grinders with sharp protuberances; crest-formed membranes on the nose; tail wholly included in the membrane which unites the hind legs. Resident in the temperate quarters of the old continent.

* 1. *R. ferrum equinum major*, Geoff. *V. ferrum equinum*, Lin. *Horse-shoe bat*. Nose shaped like a horse's shoe; ears as long as the head, and not valved; tail half the length of the body. 2. *R. ferrum equinum minor*, Geoff. *V. ferrum equinum*, var. β Lin. *Small horse-shoe bat*. Smaller in its dimensions than the preceding.

* *R. ferrum equinum major*. The hair is long, and very soft; the ears, tail, and membrane, are blackish; the upper part of the body is ash-brown, and the under a dirty white. When it fixes itself to a wall, it contracts in size, and wraps itself up in its wings, so as, at first sight, to be easily taken for a large chrysalis. It inhabits the walls and vaults of deserted castles; is common in France, Germany, &c. but rarely occurs in England. It was first observed on the continent by Daubenton, who described it with great accuracy. It used formerly to be met with in the saltpetre works be-

longing to the powder mills at Dartford, apparently allured by the prevalence of gnats about these buildings. Within these few years, it has been found, not unsparingly, in a large cavern, called *Kent's Hole*, near Torbay, on the coast of Devonshire. It has been remarked, that the slightest perforation, by shot, in the wings, makes an individual of this species instantly fall to the ground; when, in place of attempting to bite, it tries to escape, and complains by crying. Like some of its congeners, it is occasionally infested by the *nycteribia vespertilionis*, a headless and eyeless insect, of a singular structure, and remarkable for the velocity of its motions.

5. Genus PHYLLOSTOMA, Geoff. *Vespertilio*, Lin. Two or four very small cutting teeth, placed, and, as it were, serrated, between two very long canine teeth, grinders with sharp protuberances; crest-like membranes on the nose; tail very short, or almost wanting. Resident in the hot countries of the two continents.

*1. *P. spectrum*, Geoff. *Vespertilio spectrum*, Lin. *Spectre bat*, and sometimes also denominated *Vampyre*. Nose funnelled and lanceolate; ears ovate, with an inner subulate membraneous flap. 2. *P. crenulatum*, Geoff. *Crenulated bat.* A lengthened and crenulated membrane on the margin of the nose. 3. *P. soricinum*, Geoff. *Vespertilio soricinus*, Lin. *Leaf bat.* Nose elongated, and furnished with a heart-shaped, leaf-like membrane. 4. *P. hastatum*, Geoff. *Vespertilio hastatus*, Lin. *Javelin bat.* Nose furnished with a trefoil-shaped upright membrane. 5. *P. spasma*, *Vespertilio spasma*, Lin. *Cordated bat.* A double heart-shaped, leaf-like membrane on the nose. 6. *P. emarginatum*, Geoff. *Emarginated bat.* Nose with a lengthened, spear-shaped membrane, truncated at the extremities, and toothed on the margins. 7. *P. guianense. Great javelin bat of Guiana.* Above the upper lip, a spear-shaped salient membrane, with the lower margin concave. 8. *P. perspicillatum*, *vespertilio perspicillatus*, Lin. *Fleur-de-lys bat.* Nose foliate, flat, pointed.

**P. Spectrum.* Length of the body about seven inches; extent of the wing-membrane two feet; hair cinereous. Inhabits South America and New Holland. This is a smaller species than the *vampyre*, properly so called, but not less disgusting in its appearance, nor less vexatious and formidable in its depredations. The other sorts of bats usually resort to the forests, and the most deserted places; but these enter towns and cities, and, after sunset, darken whole streets. Their powers of blood-letting from the exposed extremities of persons asleep, have been celebrated by Ulloa, and confirmed by subsequent travellers; while Condamine mentions, that they had destroyed all the cattle introduced by the missionaries. At Rosehill, near Port-Jackson, more than twenty thousand spectre-bats were supposed to be seen within the space of an English mile. Some that were taken alive would, almost immediately after, eat boiled rice, and other food, from the hand; and, in a few days, became as domestic as if they had been bred in the house. Governor Phillips had a female of this species which would hang by one leg for a whole day, without changing its position; and in this attitude, with its breast covered with its wing, would eat whatever was offered to it, lapping from the hand like a cat. The smell of these creatures is reported to be stronger than that of a fox

6. Genus NOCTILIO, Geoff. and Cuv. *Vespertilio*, Lin. Generally two or four small lobated cutting teeth, but which are sometimes wanting; tusks very strong, and scarcely allowing room for the incisors, grinders with sharp protuberances, no crest on the nose; only part of the tail included in the membrane which unites the hind legs; lips and muzzle turgid.

1. *N. molossus*, Geoff. *V. molossus*, Lin. *Bull-dog bat.* Upper lip pendulous. 2. *N. leporinus*, Geoff. *V. leporinus*, Lin. *Peruvian bat.* Upper lips turgid, bifid, covered with warts; hair yellowish. 3. *N. Guianensis*, *Chauve-souris de la Guiane*. Daubent. *Guiana bat.* Ears as if flattened, or bruised; hair dark chesnut or blackish above, lighter on the under parts, and blended with cinereous on the sides. 4. *N. myoxus*, *Chauve-souris lerot volant*, Daubent. *Flying dormouse.* Wants the cutting teeth in the upper jaw; ears of middling size, with a very short flap. 5. *N. rattus*, *Chauve souris rat volant*, Daubent. *Flying rat.* Muzzle short and thick; ears large, with a very small flap. 6. *N. lepturus*, *V. lepturus*, Lin. *Slender-tailed bat.* Nostrils tubular; tail slender, with a purse-shaped cavity on each side of the wing. 7. *N. plicatus*, *V. plicatus*, Buchanan. *Plicated bat.* Nostrils round, with simple perforations; upper lip very large and folded; ears as large as the head, folded, and half pendulous.

II. SUB-ORDER. PLANTIGRADA.

None of the thumbs separated; the entire sole of the foot resting on the ground; more than two teats placed under the belly; no membrane adapted to flight; orbitary and temporal fossæ united; cœcum wanting.

The *first family* includes the *echinei*, or *hedgehog* tribe, whose characters are, cutting teeth slender and sharp, or emarginated; two weak and indistinct tusks; grinders with sharp protuberances; snout pointed, and terminating in a pretty hard cartilage; tail short, or wanting; body contracted, little elevated on the legs, and covered with short and strong spines, or dry stiff hairs; eyes moderately large; five toes on each foot; clavicles, or collar-bones, in the skeleton.

1. Genus ERINACEUS, *Herisson* of Desmar, &c. and including part of the *Erinaceus*, Lin. Six cutting teeth in each jaw, the middle ones longer than the lateral; tusks shorter than the incisors; tail short; a fleshy and indented appendage, like a cock's comb, on the external side of the nostrils; body susceptible of being rolled up like a ball, and bristling on all sides.

Urchins are small-sized animals, feeding, for the most part, on roots, worms, and the larvæ of insects, which they dig out of the earth by means of their snout. None of the species are carnivorous, nor do they willingly attack other quadrupeds. In their own defence, they roll themselves up into a ball, bristling with spines, so sharp and strong that few animals have the power of subduing them. In this passive state they remain till their adversaries have retired, when they leisurely unfold themselves.

* 1. *E. Europæus*, Lin. &c. *Common hedgehog*, or *urchin.* Ears rounded, nostrils crested, or furnished with a round flap. 2. *E. sibiricus*, Lin. *Siberian hedgehog.* Ears flat and short; no crested appendage at the nostrils. 3. *E auritus*, Lin. *Long-eared hedgehog.* With long oval ears, and crested nostrils. 4. *E. inauris. Earless hedgehog.* Without external ears.

* *E. Europæus.* This well-known quadruped, which inhabits most of the temperate parts of Europe and Asia, and some districts in Africa, is about ten inches

long, exclusively of the tail, which measures little more than an inch, and is so concealed by the spines as to be hardly visible. The nose is dusky, shaped like that of a hog, and scattered with a few hairs. All the upper parts of the body and the sides are closely covered with strong spines, of an inch in length, and very sharp-pointed, having the lower part white, the middle black, and the points white.

These animals, which are nocturnal, chiefly reside in woods, fields, and gardens, affecting the roots and decayed trunks of trees, the fissures of rocks, heaps of stones that have been gathered in meadows or vineyards, &c. In the cold season, they retire into holes for hybernating, wrapping themselves up in leaves and moss, and consequently, dispensing with those stores of provisions, which, it has been erroneously alleged, they lay up for themselves. Even in their more active moments, they are capable of enduring protracted hunger, and are never observed to drink.

In its manners, the hedgehog is mild, inoffensive, and timid; and the more that it is threatened with molestation or danger, the more closely it shelters itself under its coat of prickles. Such is the contractile power of muscle with which it is endowed, that one will sooner tear than uncoil it, unless by plunging it in water, when it swims with considerable ease. This little harmless creature, though not insensible to pain, has been known to undergo the cruel process of vivisection, without uttering a groan. The female produces, at a birth, four or five young, which are soon covered with prickles that are shorter and weaker than those of the parent. The nest is large, and principally composed of moss. Hedgehogs have been accused of sucking cows, and of carrying off fruit on the point of their prickles; but their mouth is obviously too small to admit a cow's teat; and they who have kept hedgehogs in their gardens, have never seen them attempt to climb into the fruit trees, or to stick even the fallen fruit on their spines. They are frequently introduced into houses, for the purpose of expelling the *blattæ*, or *cock-roaches*, which they pursue and devour with eagerness. The Calmuck Tartars keep them in their huts, in place of cats. Some years ago, a man was accustomed to exhibit in the *Champs Elysées*, at Paris, a large boxful of hedgehogs, which not only unrolled themselves, but allowed themselves to be handled and teased at his orders. Other instances are recorded, of individuals of this species having been completely domesticated.

The skin of this animal was used by the ancients as a clothes-brush; and, in some countries, it is applied to the muzzle of calves which are to be weaned. Though the flesh of the hedgehog is generally despised as an article of food, the Spaniards are said to prize it in Lent. Pliny foolishly affirms, that this quadruped's gall, when mixed with the brain of a bat, is a good depilatory; whilst Albertus Magnus, as if fearing to be outstripped in absurdity, recommends the hedgehog's right eye, fried in oil, as an ointment for the eyes, of such sovereign virtue as to enable a person to see as well by night as by day!!!

2 Genus Tenrec, Cuv. Erinaceus, Lin. Snout much elongated; cutting-teeth equal, six in the upper, and only four in the lower jaw; tusks long; tail wanting; prickles sometimes flexible, and bristle-like, or strong, and intermixed with flexible bristles; body of a more lengthened form than that of the common hedgehog; and less capable of being completely rolled up. Residents of the eastern countries of the old continent.

1. *T. ecaudatus*, *Erinaceus ecaudatus*, Lin. *Madagascar hedge-hog*. Ears rounded; hair yelloyish; feet tawny. 2. *T. setosus*, *E. setosus*, Lin. *Asiatic hedgehog*. No external ears; hair very long and very hard, but flexible and bristly. 3. *T. sub spinosus*, *T. jeune*, Buff. *Striped*, or *sub spinous hedgehog*. Three longitudinal bands of dingy white prickles, intermixed with bristles on the back; cutting-teeth slender and pointed.

The *Second Family*, or *soricii*, are distinguished by six or eight cutting-teeth in each jaw, of which the two in the middle, or else the two which immediately follow them, are the longest; tusks very short; grinders with sharp protuberances; snout pointed, and often moveable; lower jaw much shorter than the upper. Of this family there are two sections.

§ I. The two intermediate cutting-teeth in the lower jaw very long and projecting; feet with five very distinct toes, not calculated for digging the earth, and without any membrane between them; a long, hairy, and cylindrical tail, and external ears.

1. Genus Sorex, Lin. &c. *Musaraigne* of the French. Corresponding with the characters just recited.

The animals of this genus bear a considerable resemblance to the murine race; while the disposition of their teeth, and their habits of life, require that they should have a separate station assigned to them in the system. In some respects they have an obvious affinity to moles, particularly in the shape of their head, the smallness of their eyes, and the circumstance of their burrowing under ground. They subsist chiefly on insects, worms, dead animals, and sometimes on grain. They are usually found lurking under grass or moss, or in the deserted excavations of moles. They seem to shun the sight of man, and to seek shelter from the observation of such animals as might otherwise destroy them in great numbers. Their habitations are seldom far distant from the banks of rivers, or smaller streams; and most of them are capable of swimming with great agility.

*1. *S. musaraneus*, Lin. *Common* or *fetid shrew*, *shrew mouse*, *hardy shrew*, *shrove mouse*, &c. Rusty-brown above; whitish beneath; with the tail rather shorter than the body. 2. *S. fodiens*, Lin. *Water shrew*, black above and white beneath. 3. *S. constrictus*, Cuv. *Constricted shrew*. Tail more slender at the base than at the extremity. 4. *S. Brasilensis*, Lin. *Brazilian shrew*. Brown, with three black stripes on the back. 5. *S. murinus*, Lin. *Murine shrew*. Brown, with ash-coloured feet and tail, and the latter of middling length.

* *S. musaraneus*. The trivial name has been deduced by most naturalists who have deigned to advert to its etymology, from *mus* and *aranea*; and yet not a single analogy can be traced between the *shrew* and the *spider*. In this dilemma, we may be permitted to state, that the old French forms are *muset*, *musette*, *muserain*, and *muzeraigne*, all expressive of the prominence of the snout; and that from one of them, *musaraigne*, and the modern *musaraneus*, have taken their origin.

The ordinary length of the common shrew, from the nose to the beginning of the tail, is two inches and a half. The tail is covered with short dusky hairs. The legs are very short; and the hinder ones are placed very far back.

The shrew, which is one of the smallest of European quadrupeds, is a common inhabitant of our fields and gardens, and may, also, often be found, especially in winter, in old walls, stables, yards, granaries, dung-hills, &c. feeding on corn, insects, and offals. It diffuses such a powerful smell of musk, that though cats kill it they will not eat it. Its voice is a shrill disagreeble whistle, whence, probably, the metaphorical sense of the word *shrew*. Though incapable of biting, the vulgar believe that it inflicts by its teeth various disorders among horses and cattle. Nay, prejudice represents it as of so baneful and deleterious a nature, that, whenever it creeps over a beast, be it horse, cow, or sheep, the suffering animal is afflicted with anguish, and risks the loss of the part affected. Against this alledged misfortune, it was formerly customary, in many parts of England, to have *shrew ashes*, or ash-trees, whose twigs and branches, when gently applied to the limbs of cattle, were supposed to relieve the pains, as if by an immediate charm. A deep perforation was made into the body of the tree, and a poor devoted shrew mouse was thrust in alive, with several quaint incantations. When a horse in the fields happened to be suddenly seized with any thing like a numbness in his limbs, he was immediately pronounced, by the old farriers, to be either *planet-struck* or *shrew-run*. The mode of cure which they prescribed, and which they considered to be infallible, was to drag the animal through a piece of bramble that grew at both ends!

The female shrew is supposed to breed more than once in the year, and to bring five or six at a litter, in a nest which is usually composed of grass and moss. The species seems to be liable to an annual mortality, as many of them are found dead in the fields, highways, &c. about the month of August.

§ II. The two intermediate cutting teeth very small, the two succeeding elongated, the feet usually furnished with five toes, which are for the most part, very strong, united by a very thick skin, and armed with very strong claws, so as to be peculiarly fitted for burrowing; in some other instances, they are simply palmated, and chiefly adapted to swimming; tail wanting, or very short, or long, compressed, and scaly; no external ears.

1. Genus Mygale, Cuv. *Desman*, Desmar. *Sorex*, Lin. Snout elongated, slender, and moveable; tusks very short, tail long, compressed vertically, and, like that of rats, covered with small scales; hind feet palmated. Resident in the northern parts of the old continent.

1. *M. moschata*, *Sorex moschatus*, Lin. *Musk Shrew*. Tail naked, and thickest in the middle.

1. Genus Scalops, Cuv. *Sorex*, Erxleb. *Talpa*, Lin. The conformation of the teeth corresponding to that of the *Soricii*, and the other characters analogous to those of the *Talpii*, as indicated below. Resident in the northern parts of the new continent.

1. *S. aquaticus*, *Sorex aquaticus*, Erxleb. *Aquatic Scalops*. Hind feet palmated, fore-feet white, tail short and white. 2. *S. cristatus*. *Talpa cristata*, and *Sorex cristatus*, Lin. *Crested Shrew*. Nostrils carunculated, tail short.

3. Genus Chrysocholris, Cuv. Sorex and Talpa, Lin. and Erxleb. Teeth like those of the *Soricii*, form of the body like that of the *Talpii*, but the snout is shorter, the fore-feet are furnished with only three visible toes, and the tail is wanting. Resident in Southern Africa.

1. C. *Capensis*, *Talpa Asiatica*, Lin. *Cape Mole*. Hair gold-green, glossed with a copper hue.

The *Third Family* is composed of the *Talpii*, or *mole* tribe, which have six cutting-teeth in the upper, and eight in the lower jaw, equal to one another; two tusks longer than the incisors, in each jaw, grinders with sharp protuberances, snout pointed, lower jaw shorter than the upper, fore-feet very broad, and excavating the earth, claws and clavicles very strong, eyes very small, no external ears, tail very short, body covered with hair. Resident in both continents.

1. Genus Talpa, Lin. &c. The generic characters are, in course, coincident with those of the family.

1. * *T. Europæa*, Lin. *Common* or *European Mole*, *Moldwarp* or *Want*. Feet with five toes. 2. *T. longicaudata*, Lin. *Long-tailed Mole*. Brown, the hinder feet scaly, and the tail comparatively long. 3. *T. rubra*, Lin. *Red Mole*. Rufous, with short tail, fore-feet tridactylous, hind feet tetradactylous.

* *T. Europæa*. This subterraneous quadruped is too familiar to our observation, to require any detailed description. Suffice it to say, in general, that its structure and organization are admirably adapted to its habits and wants.

The eyes of the mole are so extremely small, that many were induced to disbelieve their existence, whilst others doubted if they were intended by nature for distinct vision. Galen, even without the aid of glasses, ventured to assert, that the crystalline and vitreous humour of these organs, accompanied with their respective tunics, were perceptible; and although this position was disputed by Sir Thomas Brown and others, yet Mr. Derham, in his Physico-Theology, declares, that he has made "divers accurate dissections of the eyes of moles, with the help of microscopes, having a doubt whether what we take to be eyes were such or no; and upon strict scrutiny, could plainly distinguish the crystalline and vitreous humours, and the ligamentum ciliare, with the atramentaceous mucus." If a live mole be put into water, the integuments which cover the ball of the eye are withdrawn, and the organs of vision may be distinctly seen, having the form and size of a grain of mustard-seed, and appearing like two black and shining points.

Moles, likes beavers, and some other animals, live in pairs, and, in humble obscurity, enjoy the sweets of domestic society. The parent animals begin the construction of their dwellings, by raising the earth, and making a pretty high arch, leaving partitions, or pillars, at certain distances, then beating and pressing the earth, interweaving it with the roots of plants, and rendering it so hard and solid, that the water cannot penetrate the vault, on account of its convexity and firmness. Under the principal arch, they rear a little hillock, on which they lay herbs and leaves, as a bed for their young, thus placing them above the level of the ground, and, consequently, beyond the reach of ordinary inundations. They are, at the same time, defended from the rains by the large vault which covers the internal one, on the summit of which they rest along with their young. This inner hillock is pierced on all sides with sloping orifices, which descend still lower, and serve as covered ways for the mother when she goes in quest of food for herself and offspring. These bye-paths are beaten and firm, extending about twelve or fifteen paces, and issuing from the principal mansion, like rays from a centre.

Linné and Gmelin have asserted, that moles are dormant in winter. That they *never* are so in the colder reigons of the earth, we cannot positively affirm; but our own observation may convince us, that they do not hybernate in this country, nor do they become torpid in the more temperate latitudes of Europe. During winter they prefer somewhat elevated spots, where they may be best secured against floods, but in summer they resort to the hillocks and flat lands, especially to meadows, where they find the earth fresher, softer, and more abundantly provided with insects. Their holes are seldom more than five or six inches under the surface of the soil. In forming one of them, the animal scrapes the mould before it on one side, till the quantity becomes too great for it to labour onward with ease, when it works towards the surface, and, by pushing with its head and the assistance of its nervous paws, it gradually heaves up the earth which incommodes it, and thus produces those small hillocks which are so common in our fields. After getting rid of the earth in this manner, it proceeds forward and continues its labours as before. So expert are these little creatures in forming a passage for themselves in the ground, that if they are put on the grass in a field where the soil is tolerably light, they will force their way into it, and cover themselves almost in a moment. Even on a gravelly and hard turnpike road, a mole has been known to cover itself completely in less than five minutes. The soil, however, which they preferably affect is neither pure sand nor clay, but mould that is frequented by worms. Such relentless persecutors are they of the latter, that, by thrusting a spade into the ground, and shaking it, the worms, believing the motion to be produced by the moles, immediately come to the surface, and are thus caught for bait by the angler. Dr. Walker states that he has observed mole hills at the distance of 2000 feet above the level of the sea.

The female brings forth four or five young about the month of April; but as young ones are often observed in August, Buffon correctly conjectured that there is frequently a second brood. The new-born moles are quite naked and red, and continue so till they have attained a considerable size. In some places, the race certainly multiplies to an astonishing degree, so as to prove highly prejudicial to the labours of the husbandman. In 1742, a single farmer in Holland caught between five and six thousand of them. We are informed too, that, in ancient times, the inhabitants of Tenedos, the Trojans, and the Eolians, were seriously annoyed by their pullulation, and that a temple was erected to *Apollo Smynthius*, the *destroyer of moles*.

These quadrupeds are capable of swimming over brooks and narrow pieces of water, without difficulty. They are observed to cast up most earth immediately before rain, and in winter immediately before a thaw, because at those times the worms and insects begin to be in motion, and to approach the surface. In very dry weather, on the contrary, they seldom or never form any hillocks, as they descend in pursuit of their prey, which, at such seasons, retires far into the ground. During the summer months, they will in the night-time run among the grass in search of snails and worms, when they are liable to be devoured by the owl and other rapacious animals. When first taken, either by digging or otherwise, moles usually utter a shrill scream, and prepare for their defence, by exerting the strength of their claws and teeth. They are with difficulty kept alive in a state of confinement, unless they are constantly supplied with damp mould in which to reside.

This species seldom occurs except in cultivated regions, being scarcely known in parched deserts, or in those countries which are consigned to almost perpetual frost. The Linnéan epithet, *Europæa*, is obviously incorrect, since the mole has been traced not only in Africa, but in some parts of Asia. A white variety has been occasionally met with in Lorraine, Holland, and Switzerland; and Sonnini alludes to an individual found near Nancy, that had the upper part of the body fawn-coloured, and the lower of a glossy white.

The flesh of the mole has the savour of that of the rabbit, and is reckoned a great delicacy by the Arabs. The difficulty of manufacturing the skin greatly detracts from its value; but ladies past their prime, have sometimes recourse to prepared portions of it, as substitutes for eye-brows.

Animals of the *Fourth Family*, denominated *Ursini*, have the cutting teeth in each jaw, the two lateral of the lower jaw longer than the rest; two strong tusks; grinders with a somewhat flattened crown, and the last of them with blunted protuberances, separated by deep channels; on each foot five toes, armed with crooked and sharp claws; body thick, and covered with hair; limbs short; eyes of middling dimensions; ears external; clavicles in most instances wanting.

1. Genus Ursus. The upper jaw not greatly exceeding the lower; a small obtuse tooth behind each tusk, and then a vacant space to the grinders; the second cutting tooth in the lower jaw not projecting into the mouth; body not lengthened in proportion to its size; legs pretty long; tail very short; no bone in the penis.

* 1. *U. arctos*, Lin. &c. *Common* or *brown bear*. Blackish brown, tail short. * 2. *Ursus maritimis*, Lin. *Polar* or *great white bear*. White, with elongated neck and head; tail abrupt. 3. *U. gularis*, Geoff. *American*, or *gular bear*. Black, with rust-coloured cheeks and throat.

* *U. arctos*. See Bear.

* *U. maritimus*. See Bear. (Plate CCCLIII. Fig. 8.)

2 Genus Taxus, Cuv. *Ursus*, Lin. Upper jaw not much exceeding the lower; grinders forming an uninterrupted series to the tusks; no small subsidiary tooth behind the latter; body of a more lengthened form than in the *Ursi*, and placed lower on the limbs; tail of a moderate length, and hairy; a sack under the tail, containing a fetid humour. Resident in both continents.

* 1. *T. meles*, Cuv. *Ursus meles*, Lin. *Badger*, *brock*, *grey pale*, or *grey*. Body cinereous above, black beneath; a longitudinal black stripe, including the eyes and ears; tail of the same colour with the body. * 2. *T. gulo*, *U. gulo*, Lin. *Glutton*. Body and tail tawny brown, middle of the back black. * 3. *T. mellivorus*, *Viverra mellivora*, Lin. *Ratel*, or *honey weasel*. Body cinereous; lateral band and belly black; claws long, hollow underneath, and formed for digging.

* *T. meles*. The usual length of the badger is two feet six inches, exclusively of the tail, which is at most six inches long, and covered with long hairs. The weight varies from fifteen to thirty, or even thirty-four pounds; but the last is very rare. The throat and under parts of the body are black; whereas most other quadrupeds have the hair on the belly of a lighter colour than on the back. Redinger figures a singular variety of the species, of a white colour, with brown and reddish patches.

The badger inhabits all the temperate, and some of the colder regions of Europe and Asia, and is not uncommon in our own island, particularly in Sussex, Essex, and some of the inland counties of England. It haunts woody tracts, and dwells in the clifts of rocks, or in burrows which it forms in the ground. Though there is but one entrance from the surface to its subterranean abode, it forms several apartments; and, in the breeding season, carries in grass in its mouth, with which it makes a bed for its young. During the severity of winter it remains in a half torpid state, sleeping on a commodious bed formed of dried herbage. Badgers usually live in pairs; but they separate once a-year in spring, when the dam produces her litter of four or five young. These are easily tamed, will play with dogs, and follow the person who feeds them. In confinement, they eat almost every thing that is offered to them, sleep very much, and get very fat. They are so chilly, that, when permitted to range at pleasure about a house, they will scarcely ever quit the fire; and they often approach so close to it as to burn themselves. Although very strong, and capable of biting hard in its own defence, the badger is devoid of the cruelty and fierceness which have been ascribed to him; and so far is he from destroying lambs and rabbits, that he seldom attacks any animal larger than a frog or a lizard, on which, and on insects, fruits, grass, roots, &c. he principally feeds. In China, badger's flesh is a very common article of food. In this country only the hind quarters are eaten, and chiefly in the form of hams. The skin, dressed with the hair on, is used for pistol furniture, and pendent pouches for our Highland soldiers. The hair is also made into brushes for softening and harmonizing the shade in painting, and which accordingly are technically called *sweetening tools.*

* *T. gulo.* The length from nose to tail is twenty-eight inches, and from the trunk of the tail seven inches. The tail is covered with thick and long hairs, reddish at the bottom, and black at the tip. The hairs on the head, back, and belly, are of the same colours, but much finer and softer. The throat is whitish, marked with black. Along the sides, from the shoulder to the tail, is a broad band of a ferruginous hue. It is to be observed, however, that the animal varies considerably in colour; sometimes appearing black, with a sub-ferruginous lateral band; and at other times of a chesnut tinge.

The glutton, which has its name from its voracity, is found in all the countries bordering on the Northern Ocean, both in Europe and Asia. It is likewise not uncommon in Canada, the country about Hudson's Bay, and other parts of North America. It has much the manners of the bear; and though in fierceness little inferior to the wolf, it is very capable of being tamed. Most quadrupeds which it ventures to assail, except the beaver, outstrip it in the course; but it lurks in the branches of trees, to surprise the rein-deer and other animals as they pass, waiting with great patience the occurrence of its prey, and darting on it with unerring aim. Its appetite for animal food is keen and indiscriminate; but the accounts of its eating till its skin gives way, of its squeezing itself between two trees to unload its stomach, &c. are gross exaggerations. A tame one, which was kept at Dresden, and exhibited as a performer of tricks, would eat thirteen pounds of flesh in a day, without appearing to be satisfied. That which Buffon possessed, on the contrary, consumed only four pounds of meat daily; and another, which belonged to the Hudson's Bay Company, was contented with the ordinary allowance of a mastiff dog: whence we may infer, that in the brute creation, as in the human, very considerable diversities in regard to appetite may take place, even among individuals of the same species.

The flesh of the glutton is tough and unsavoury; but the animal is hunted on account of its skin, which shines with a peculiar lustre, and reflects the light like damasked silk.

From some recent observations, it should seem that *Ursus luscus* of Linne, the *quickhatch*, or *wolverene*, is only a variety of this species.

* *T. mellivorus.* Length from nose to tail two feet, and that of the tail eight inches. A broad ash-coloured stripe extends along the back from the forehead to the tail, and is separated from the black hair on the side and belly by a light-grey list, running from behind each ear to the tail.

The ratel is a native of the Cape of Good Hope where it is remarked for its singular faculty of discovering and attacking the wild bees in their habitations. Towards sunset, it is particularly attentive in watching the motions of these industrious insects, following with great care the direction in which they fly. In its predatory range, it is not unfrequently assisted by the *Cuculus indicator*, a bird which excites its attention by a loud grating cry, flying at the same time slowly forward to the place where a swarm of bees have taken up their abode. The ratel follows the sound with great attention, and, having plundered the nest, leaves enough behind as a reward for the services of its guide. Owing to the toughness of its skin, it has little to dread from the stings of the insulted bees. The nests, however, which are built on trees, are beyond its reach. In the first transports of its rage, it gnaws and bites the trunk; and these bites are sure marks for the inhabitants that a bees' nest is to be found there. We are aware of Mr. Bruce's scepticism on this subject; but the facts which we have just stated are confirmed by Sparmann and Barrow.

3. Genus Procyon, Cuv. *Ursus*, Lin. Upper jaw not much exceeding the lower; no vacant space between the tusks and grinders; body lengthened, and a little higher on the legs than that of the *Taxi*; tail very long and hairy. Resident in the new continent.

* 1. ***P. lotor***, ***Ursus lotor***, Lin. ***Raccoon.*** Tail ringed; a black stripe across the eyes. 2. ***P. cancrivorus***, ***Persian raccoon.*** Deep rufous above; light coloured beneath; and nearly white at the tail and in the inside of the ears.

* *P. lotor.* The length of this animal is two feet from nose to tail, and that of the tail about one foot. The omentum has a very remarkable structure, being comparatively large, and consisting of innumerable stripes of fat, disposed in a reticulated form, and connected by an extremely delicate membrane resembling a spider's web. Buffon had rather inadvertently limited the native abode of the raccoon to South America, whereas it chiefly occurs in the temperate quarters of North America, and in the mountainous districts of the West Indies. From the high grounds in Jamaica, multitudes of them frequently descend into the plantations, and make great havoc among the sugar canes. They likewise greedily devour maize, various sorts of fruits, eggs, birds, and shell fish, and are particularly fond of oysters and crabs. Brickell informs us, that one of them will stand on the side of a swamp, and hang its tail over into the water, while the crabs, mistaking it for food, lay hold of it; and as

soon as the creature feels them pinch, he pulls them out with a sudden jerk. He then takes them to a little distance from the water's edge, and, in dispatching them, is careful to get them crossways in his mouth, lest he should suffer from their nippers. The land crab he takes, by putting one of his fore paws into the ground, and dragging it out. The raccoon sleeps from noon till midnight, feeding chiefly in the dark. He is an active and sprightly animal, moving forward chiefly by bounds; and although he proceeds in a singularly oblique direction, he runs very swiftly. His sharp claws enable him to climb trees with great facility; and he ventures even to the extremities of the branches. He is easily tamed, and is then good-natured and sportive, though somewhat capricious, and always restless, manifesting at the same time the plaguy and inquisitive disposition of the monkey, examining every thing with his paws, which he uses as hands. He eats in a sitting posture, and is very partial to sweetmeats and strong liquors. He drinks both by lapping and suction, washes his face with his feet like a cat, and immerses most of his food in water before eating it.

Valmont de Bomare, in his Dictionary of Natural History, under the article *Raton*, mentions that one was exhibited in Paris, in 1766; but the particulars which he notices are obviously inapplicable to the present species, and add one to the many inaccuracies with which that popular compilation abounds.

The flesh of the raccoon is regarded as a dainty by the negroes; but the animal is chiefly hunted for the sake of its fur, which the hat-makers reckon next in value to that of the beaver. The skins, when properly dressed, make good gloves and upper shoe-leathers.

4. Genus KINKAJOU, Geoff. and Cuv. *Viverra*, Lin. Upper jaw not much exceeding the lower; snout short; body slender; legs long; tail naked underneath, prehensile, and longer than the body.

1. *K. caudivolvus*, *Viverra caudivolvus*, Lin. *Prehensile-tailed weasel*, or *Kinkajou*. Yellow, shaded with dusky.

5. Genus NASUA, Geoff. *Viverra*, Lin. The upper jaw greatly projecting beyond the lower; nose moveable in every direction; body lengthened; pretty high on the legs; tail very long and hairy. Resident in the new continent.

1. *N. nasica*, *Viverra nasua*, Lin. *Brownish Coati.* Brownish; tail of the same colour; nose elongated. 2. * *N. rufa*, Geoff. *Viverra nasua*, Lin. *Coati-mondi*, or *Brazilian Weasel.* Tawny; tail ringed with white. 3. *N. pusilla*, Geoff. *Little Coati*, or *Little Martin of Guiana.* Like the preceding, but of smaller dimensions. 4. *N. quasje Viverra quasje*, Lin. *Quasje.* Chesnut colour above, yellowish beneath, tail ringed.

* *N. Rufa.* In the length of its hind legs, the form of its feet, the bushiness of its hair, and the structure of its paws, this quadruped has such a resemblance to the bear, that Cuvier has arranged them in the same genus. The coati-mondi is about the size of a cat; inhabits Brazil and Guiana; runs up trees very nimbly; digs for worms; eats mice and other small animals, as well as bread, roots, and fruit. It stands with ease on its hind feet; eats like a dog; and holds its food between its fore-legs like the bear. It is said to gnaw its own tail, which it generally carries erect, or sweeps about from side to side. When irritated, it emits, like its congeners, an intolerable odour.

III. SUB-ORDER. CARNIVORA.

No separate thumbs; hind feet resting only on the toes; more than two teats placed under the belly; no membrane adapted for flight; tail never prehensile; number of toes varying from four to five; claws hooked and sharp; body always covered with hair; temporal and orbitary fossæ united; a cæcum in most of the species; clavicular bones in the flesh.

The *First Family* comprises the *Mustelini*, which have six cutting-teeth in each jaw; the second on each side of the lower, entering into the mouth; body generally long and cylindrical; legs short; claws almost demi-retractile and pointed, but slightly cutting; iris contracting circularly; for the most part corneous papillæ under the tongue; external ears short, or scarcely apparent; cæcum commonly wanting.

1. Genus SURICATA, Desmar. *Ichneumon*, Geoff. *Viverra*, Lin. Four free toes on all the feet; claws very strong, compressed, sharp-edged, and not retractile; snout elongated, and projecting much beyond the lower jaw; nose moveable; no papillæ on the tongue; ears short and rounded; soles of the feet very long; body more squat; tail shorter and stronger than in the next genus; a bag under the anus, containing an unctuous secretion; cæcum present. Resident at the Cape of Good Hope and in the Island of Java.

1. *S. Capensis.* Desmar. *Viverra tetradactyla*, Lin. *Four-toed weasel* or *Surikate.* Characters the same as of the genus.

2. Genus MUNGO, *Mangouste*, Desmar. &c. Five separate toes on each foot; short, but very hard pointed, and demi-retractile claws; under the tail a sac, from which exudes a particular humour; the snout not much exceeding the lower jaw; the tongue rough with papillæ; tail very long, very vigorous, and very pointed; external ears short and rounded; cæcum small.

1. *M. Indicus*, *Ichneumon Indicus*, Geoff. *Viverra mungo*, Lin. *Indian weasel.* Tail thick at the base, tapering, and tipt with black. 2. *M. Cafer*, *Ichneumon Cafer*, Geoff. *Caffrarian weasel.* Yellowish-brown; gradually tapering tail, tipt with black. 3. * *M. Egyptius*, *Ichneumon Egyptius*, Geoff. *Viverra ichneumon*, Lin. *Ichneumon* or *Egyptian ichneumon.* Tail thick at the base, tapering, and not tufted; great toes remote.

M. Egyptius. (Plate CCCLIV. Fig. 9.) This animal varies much in size, but is generally somewhat longer in the body, and shorter in the legs, than the common cat; whilst its form and shape somewhat resemble those of the polecat. Its fur is agreeably diversified with tints of white, brown, fawn-colour, and a dingy silver-grey. But the depth and cast of colouring vary in different individuals. The hair of the body is coarse and wirey; the eyes are small, but red and glowing; and the ears small, rounded, and almost naked. A very fetid humour is secreted from an orifice under the tail. This creature has a small, soft, murmuring voice, which it hardly ever exerts, unless when it is struck or irritated. When it sleeps it rolls itself up like a ball, and is not easily roused from its slumbers. It frequently sits up like a squirrel, and feeds itself with its fore feet, catching any thing that is thrown at it; and will often feign itself dead till its victim comes within its reach, when it darts on it like an arrow, and seizes it with inevitable certainty. Its range of prey is wide and various, from animals larger than itself to the eggs of poultry, and from the most venomous snake to the most harmless lizard. Its natural appetite for eggs prompts it to ransack the sand, in which it sometimes finds those of the crocodile, which it devours with great greediness. It also dispatches a very young crocodile in an instant; but that it darts down the throat of the large ones, and destroys them by gnawing their entrails, is a mere fable. From its inveterate enmity to serpents, rats, and other noxious animals that infest the hotter regions of the globe, it has been regarded by the inhabitants with feelings of gratitude, and in Egypt, in particular, it was long treated with divine honours. According to Sonnini, neither the name of *Ichneumon*, nor that of *Pharaoh's Rat*, is now known in Egypt. The Arabic appellation of the species is *Nems*, which Buffon, from want of accurate information, describes as a distinct animal. The ichneumon was, without doubt, one of the sacred animals of ancient Egypt; particular care was taken of it when alive, and honours were paid to it after its death; funds were assigned for its maintenance, and it was fed, like the cat, with bread soaked in milk, or with the fish of the Nile, cut in pieces; and it was everywhere forbidden to kill it. With great dispositions to familiarity, it is not now domesticated in Egypt, nor do the inhabitants of that country recollect the period when it was reared in the house. "If some ichneumons," observes Sonnini, "have been seen flying with fury at the little crocodiles that have been offered to them, it must have been the effect of their appetite for all sorts of reptiles, and not, as many persons have supposed, that of a particular enmity, or of a law of nature, which specially impelled them to check the multiplication of those amphibious animals. It would, at least, have been as reasonable to suppose that nature created the ichneumon on purpose to prevent the superfluous propagation of poultry, which, in fact, it destroys in a much greater proportion than it does crocodiles. Besides, in more than one half of the northern part of Egypt ichneumons are very common, where no crocodiles exist, while they are more scarce in upper Egypt, where crocodiles are very numerous. The ichneumon is nowhere more multiplied than in lower Egypt, which, being better cultivated, more populous, more moist, and more shady, affords a more abundant supply of food and prey; and yet crocodiles are there never seen."

3. Genus Martes. Five separate toes on each foot, claws short, hooked, very hard-pointed, and demi-retractile; body of an equal diameter throughout, and often arched; tail cylindrical, hairy, of moderate length, and scarcely thicker at the base than at the extremity; ears rather longer than in the preceding genera of the family; hair long; cæcum wanting.

* 1. *M. vulgaris*, *Mustela vulgaris*, Lin. *Weasel*, *Mouse-hunt*, or *Vare*. *Whitret* of the Scotch. Body tawny-brown above; white breast; tail of the same colour as the body. * 2. *M. furo*, *Mustela furo*, Lin. *Ferret*. Eyes red and fiery; body yellow or whitish.

* 3. *M. foina*, *Mustela foina*, Lin. *Martin*, *common*, or *White-breasted martin*, *Marten cat*, *Sweet mart*, or *Martlet*. Body blackish-tawny; throat and breast white. 4. *M. striata*, *Mustela striata*, Lin. *Striated weasel*. Blackish, with five parallel white stripes on the back. 5. *M. vittata*, *Mustela vittata*, Lin. *Grey weasel*, or *Grison*. Blackish, with a white fillet from the forehead to the shoulder. 6. *M. abietum*, *Mustela martes*, Lin. *Pine martin*, *Pine weasel*, or *Yellow-breasted Martin*. Body blackish-tawny; throat and breast yellow. 7. *M. rufa*, *Mustela rufa*, Geoff. *Rufous weasel*. Brown, varied with small lines of fawn brown; tail black. * 8. *M. erminea*, *Mustela erminea*. Lin. *Ermine*, or *Stoat*. Tail black at the tip. * 9. *M. zibelina*, *Mustela zibelina*, Lin. *Sable*. *Sable weasel*, or *Ice fox*. Body dark tawny; forehead white; throat cinereous. 10. *M. vison*, *Mustela vison*, Lin. *Vison*. Body entirely of a deep chesnut hue; tail tawny. 11. *M sarmatica*, *Mustela sarmatica*, Lin. *Sarmatian weasel*. Upper part of the body yellow and brown. * 12. *M. putorius*, *Mustela putorius*, Lin. *Pole-cat*, *Foumart*, quasi *Foul mart*, *Foul*, or *Stink-Martin*, or *Fitchet*. Body blackish-yellow; mouth and ears white. 13. *M. galera*, *Mustela galera*, Lin. *Galera weasel*. Entirely brown. 14. *M. barbara*, *Mustela barbara*, Lin. *Guiana weasel*. Black, with a white trilobate spot below the throat. 15. *M. quiqui*, *Mustela quiqui*, Lin. *Quiqui*. Brown, with wedge-shaped snout. 16. *M. Sibirica*. *Siberian weasel*, or *Chorak*. Body tawny; feet very hairy. 17. *M. ictis*, *Boccamele*, or *Sardinian Weasel*. Hair six or eight lines long; tail black. 18. *M. pekan*, *Pekan*. Body blackish tawny; a white spot on the breast.

* *M. vulgaris*. The weasel is the smallest of its tribe, not exceeding two inches and a half in height, nor seven inches and a half in length, from nose to tail. The latter, which is only two inches and a half long, terminates in a point, and adds considerably to the apparent length of the body. Its prevailing colour is a pale tawny-brown on the back, sides, and legs; the throat and belly are white; and beneath the corners of the mouth, on each jaw, is a spot of brown. The eyes are small, round, and black; and the ears, which are broad and large, have the appearance of being double. It is a common inhabitant of the cold and temperate regions of Europe, Asia, and America; and it has even been observed in Barbary and Egypt. Its habits, in general, correspond with those of the congenerous species. It is particularly destructive to young birds, poultry, rabbits, &c. and it sucks the contents of eggs with great avidity. The hare, panic-struck at the very sight of this apparently insignificant enemy, yields to it without resistance, uttering, at the same time, the most piteous cries. The bite of the weasel is generally fatal; for it seizes its prey near the head, and, with its small sharp teeth, instantly pierces the jugular vein. Scarcely any place is secure from its intrusion, as it runs up a wall with the greatest ease; and such is its flexibility of structure, that it has been known to make its way through a hole only seven lines in diameter. It sleeps during the greater part of the day, and usually employs the night in exercise and eating. When asleep, its muscles are in such a flaccid state, that it may be taken up by the hand, and swung backwards and forwards, like a pendulum, several times, before it is roused from its slumbers. During winter, it frequents barns, out-houses, and granaries, which it effectually clears of rats and mice, being a more deadly foe to the murine race than the cat itself, pursuing them into their holes, and killing them after a short resistance. In summer, it roams to some distance from its usual haunts, and is frequently found by the sides of waters, near corn-mills, &c. Towards the close of the day, it may be seen stealing from its hole, and creeping about the farmer's yard in quest of game. Though it usually sucks the warm blood of the animals which it kills, it seldom eats them till symptoms of putrefac-

tion are preceptible; so that a considerable quantity of prey is sometimes found accumulated in its retreat. Its odour is strong and offensive, especially during hot weather, or when it is pursued or irritated. It is less nimble than some of its tribe, and might often be overtaken by school-boys, had it not generally the cunning to climb up into the first tree that occurs. The female brings forth in spring, and usually four or five at a litter, which she accommodates with a bed of straw, leaves, and moss. Though born blind, they soon acquire strength enough to assist in the nightly excursions, when they will attack serpents, water rats, moles, field-mice, over-run meadows, and frequently kill partridges, and suck their eggs.

Buffon, who, in the first edition of his celebrated work, had represented the ermine and weasel as alike untameable, had, subsequently, the candour to publish some interesting extracts from letters from persons of respectability, which clearly prove that both these species may be rendered extremely gentle, docile, and playful. From these, and similar details, we may likewise infer, that the characters and dispositions of individual weasels present considerable varieties and shades of difference. We have to observe, however, that unless the requisite attention and discipline be bestowed on them, when the animals are yet young, they will afterwards be lavished in vain; for the old ones, when in confinement, are in perpetual agitation, appear much disturbed at the sight of man, refuse to eat in any person's presence, and usually, if not allowed to take shelter in some hidden place, soon die.

The weasel's fur forms an article of commerce in some of the northern countries. Those procured in Siberia are principally sent to China, where they sell for three or four rubles a-piece.

* *M. furo.* (Plate CCCLIV. Fig. 10.) The ferret, in its general form, so much resembles the pole-cat, that some have supposed them to be of the same species; but though they even occasionally intermingle, the offspring is hybrid and equivocal. The ferret, besides, is a small animal, its usual length being about 14 inches, exclusively of the tail, which is five inches; its body, too, is more slender than that of the pole-cat; its colour is very pale yellow; and, according to Daubenton, it has fifteen ribs, whereas the pole-cat has only fourteen. The ferret, moreover, has an additional bone in the sternum; and, as laid down in the specific definition, flame-coloured eyes. The history of this quadruped strongly corroborates these proofs of distinction; for we learn from Strabo, that it was imported from Africa into Spain, probably for the purpose of extirpating the rabbits with which that part of Europe was over-run; and we know that it is only domesticated in the most temperate regions, and betrays an extreme impatience of cold. Though easily tamed to a certain degree, it is of an irascible temper; and, when irritated, its odour, which is at all times unpleasant, becomes far more so than usual. It is, therefore, kept almost exclusively for dislodging rabbits, and requires to be sheltered in a box, lined with wool, or in some other warm repository. It passes great part of its time in sleep; and, when it awakes, it immediately begins to search about for food. It is usually fed with bread and milk, but delights more in the blood of the smaller animals. When angry, it is apt to bite, and inflicts a wound that is not easily healed. The female goes six weeks with young, and breeds twice a-year. Some of them devour their new-born offspring, when they immediately come in season again, and still have two litters, each of which generally consists of five or six, but sometimes seven or eight, or even nine. So inherent and inveterate is the enmity of the ferret to the rabbit, that it would kill the latter in its hole, if it were not muzzled, when admitted into the warren. It has sometimes been employed with great success in killing rats, of which it will not suffer one to live in its neighbourhood. In this respect, it is particularly serviceable about mills and granaries, and might be equally so on shipboard, if it could there be kept comfortably warm.

**M. foina.* About eighteen inches long, the tail ten inches, and full of hair, especially towards the end, which is thick and bushy. This is one of the most elegant British beasts of prey, and very graceful and springy in its motions. It is a native of most parts of Europe, and has the habits of the family. It is a great enemy to cats, and will even successfully attack the wild cat. Its musky scent is very grateful to dogs. When taken young, it is easily tamed, and becomes extremely good-humoured and playful; but it readily takes advantage of the first opportunity of regaining its liberty. The female produces from three to seven at a time, and is supposed to breed twice a-year, generally in spring and autumn. The breeding place is usually the hollow of a tree, lined with moss; a hay-loft; a hole in a wall, stuffed with straw or grass, and sometimes the cleft of a rock. Like others of its tribe, the martin is very subject to worms. In some countries, its flesh makes an article of food; but persons unaccustomed to it, do not much relish its musky flavour. The fur is much in request for lining or trimming the robes of magistrates and other dignified functionaries.

**M. erminea.* This species is called *ermine*, when the body is *white*, and *stoat*, when it has a reddish tinge; so that, in most cases, the same animal has a summer and a winter appellation, at least in the northern regions, where it regularly changes colour; but, in our own country, and other temperate districts, it is not uncommon to find it party-coloured, or white in some parts, and brown in others, the change not having been completed. The ermine measures ten inches from the nose to the origin of the tail, the tail itself being about five inches and a half. It chiefly haunts woods, hedges, and meadows, especially where there are brooks, whose margins are covered with small bushes; more rarely it is also observed about barns and out-houses. In this country, both it and the weasel are sometimes found white, when they are confounded under the denomination of *white weasel;* but the black tip of the tail may always suffice to discriminate the ermine. Its fur is much valued for ornamental parts of dress.

* *M. zibelina.* This animal considerably resembles the preceding, but has a longer or sharper head, more lengthened ears, and a much shorter tail. Its colours are very liable to vary, not only in different climates, but in the same individual at different seasons; and most of the descriptions of naturalists are taken from skins procured during the winter, when the fur has assumed its darkest hue. The great residence of the sable is in northern Asia; but the species seems also to be diffused over the northern tracts of the American continent. The fur, we need scarcely observe, forms an important article of commerce, being in high request, both on account of its dark glossy hue, and of the hair turning with equal ease to either side. The

darkest furs are the most prized; a single skin, though not above four inches broad, being sometimes valued at 15*l*.

* *M. putorius.* The general length is about seventeen inches, exclusively of the tail, which measures about six inches. This well-known species is active, bold, and nimble, and will climb up a wall with great agility. When running, its belly seems to touch the ground; and, in preparing to leap, it arches its back, so as to enable it to spring with the greater force. It is very destructive to game of all kinds, makes great havoc in a rabbit-warren, approaches houses, lodges in hay-lofts, barns, and unfrequented places, and sallies forth at night in quest of prey, invading the poultry, pigeons, and even the bee-hives. In summer, it often resides in woods, or thick brakes, where it burrows under ground, forming a shallow retreat, about two yards in length, and commonly ending among the roots of trees. It is so fierce and bold, that it will defend itself against a dog with great spirit, attack in turn, and fasten on its adversary's nose with so keen a bite, as frequently to compel him to desist. Its odour is proverbially offensive, and, when the creature is heated or irritated, highly fetid. Even dogs reject its flesh, and its fur yields a very inferior price. It occurs in most parts of Europe, from Italy to Poland, and is most plentiful in the most temperate districts. It also inhabits Asiatic Russia. This species breeds in spring, the female producing three or four at a birth, which she is said to suckle only for a short time, accustoming them early to extract the blood from the animals, and the contents from the eggs, which she fetches to them.

4. Genus MEPHITIS, Cuv. VIVERRA, Lin. Body more protuberant towards the hinder extremity than in the preceding genus, and the claws much longer and weaker; tail very bushy; glands near the anus, which secrete a highly fetid humour; cæcum present; the other characters coincident with those of the preceding genus. Resident in the new continent.

Species. 1. *M. chinche*, *Viverra mephitis*, Lin. *Mephitic-weasel*, *Chinche*, or *Skunk*. Brown, with white back, marked with a longitudinal black stripe. 2. *M. conepatl*, *Conepatl*. Blackish, with two white lines on the back, extending to the tail. 3. *M. chiliensis*, *M. mapurito*, La Cépède, *Mapurito*. Black, with a snowy band from the forehead to the middle of the back. 4. **M. zurillo*, *V. zurillo*, Lin. *Zurillo*, or *Yaguaré*, Variegated with black and white. 5. *M. vulpecula*, *Viverra vulpecula*, Lin. *Coasse*, *Squash*, or *Stifling*. Of a dark chesnut hue, with lengthened snout.

* *M. zurillo.* About seventeen inches long, without reckoning the tail, which measures nearly six inches, independently of the hair. This animal is a native of South America, but is not found beyond 29½ degrees of south latitude. It frequents the fields; and, though apparently indifferent to the sight of people, if it perceives that it is pursued, it first contracts its body, then swells, throws its tail over its back, and darts, with unerring aim, at any person who approaches within six feet of it, a phosphoric liquor, of such potent odour, as to repel both men and dogs. If a single drop of this fluid be deposited on any article of wearing apparel, the latter should be instantly consumed or thrown away, else it will fill the house with an insufferable stench, which is not to be removed by repeated washings. M. d'Azzara affirms, that he has been often incommoded by this horrible scent at more than a league's distance; and that if the zurillo should open his artillery in the heart of Paris, every house in that great city would be polluted.

5. Genus LUTRA, Desmar. and Erxleb. MUSTELA, Lin. *Otter.* Five toes united by a membrane, on each foot; claws strong, long, and flat; head rounded, and slightly flattened in front; ears very short; tail of moderate length, very strong, pointed, and almost depressed; hind feet placed very near the tail; bristles of the whiskers resembling those of the seal, very long, and very stiff. Resident chiefly in the northern and aquatic districts of both continents.

The otters differ from the weasels, by living much in the water, whence they derive their principal subsistence; but most of the species will live even on carrion, when fish cannot be procured; and some of them also devour frogs, and other reptiles. When compared with weasels, too, they are animals of large size. None of them are able to climb into trees, nor to leap like those of the weasel tribe: but they swim with great ease and readiness, both on the surface of the water and beneath it. None of them, however, are capable of continuing immersed for a long time together, without putting their nose above the surface, to expel the foul air from their lungs, and receive a fresh supply. Hence, none of the species can, strictly speaking, be denominated *amphibious*. In fact, they all live on land, having burrows or dens on the banks of lakes or rivers, out of reach of the water, but at the same time in the neighbourhood of their usual prey.

* 1. *L. vulgaris*, Erxleb. *Mustela lutra*, Lin. *Common otter.* Brown, with naked feet, and tail as long as the body. 2. *L. lutreola*, *L. minor*, Erxleb. *Mustela lutreola*, Lin. *Smaller otter.* Blackish-tawny, with hairy feet, equal toes, and white muzzle. 3. *L. marina*, Erxleb. *Mustela lutris*, Linn. *Sea otter.* Black, with hairy feet and very short tail. 4. *L. Brasiliensis*, Erxleb. *Brazilian otter.* Black, with yellow throat. 5. *L. Canadensis*, *Mustela Hudsonica*, La Cepède. *Canadian otter.* Fur black and smooth.

* *L. vulgaris.* The usual length of the otter, from the tip of the nose to the base of the tail, is three feet three inches, and of the tail itself sixteen inches. The male weighs from 18 to 26, and the female from 13 to 22 pounds. The eyes, which are small and sparkling, are placed nearer the nose than is usual in quadrupeds, and so situated as to discover every object that is above. This facility of looking upwards affords the otter a particular advantage, when lurking at the bottom for its prey; for the fish cannot readily perceive what is beneath them, while the otter seizes them by the belly with little exertion. The lips are very muscular, and capable of being brought close together, so as firmly to shut the small opening of the mouth when the animal is in the act of diving. The legs, though short, are remarkably broad and muscular, and the joints so loosely articulated, that the animal can turn its limbs quite back, bring them on a line with the body, and use them as fins. In place of a heel, there is a round ball under the sole of the foot, by which its track, termed its *seal*, is easily distinguished in the mud or snow.

The common otter occurs in almost every part of Europe, as well as in the colder regions of Asia, inhabiting the banks of lakes and rivers, and feeding principally on fish. It is also met with in North America. In forming its retreat, it manifests no ordinary sagacity, making the entrance to its hole under the water, working upwards to the surface of the earth, and constructing several lofts or lodges, to secure an asylum in the event of high floods, leaving a small orifice for the admission of air; and even this opening, for the sake of concealment, frequently in the middle of some thick bush. It is a very cleanly animal, being extremely careful to repose in a dry place, and to deposit its excrement on an appropriate spot. On the least alarm, it flies to the water, where, by its rapidity in swimming, it frequently escapes from its pursuers. It has been asserted by Linné, and some other naturalists, that it never enters into salt water; but it has been often observed both swimming and searching for prey in the sea, particularly among the Orkney Islands, where it hunts both the cod and conger. In its visits to the ocean, it sometimes intermixes with seals in the pursuit of sea-fish. Near the Land's End, six or eight of them have been seen together, far removed from any river. In chasing its prey in a river, the otter is observed to move against the stream. The moment that it catches a fish, it drags it on shore and devours it to the vent; but, unless pressed by extreme hunger, it leaves the remainder, and betakes itself to the water in quest of more; but, for the most part, it will eat none that is not killed by itself, and perfectly fresh. Though sly and cunning, it is also very fierce, and, when attacked, will defend itself with vigour and courage to the last. The female brings four or five young in May or June. Contrary to what is remarked of most other animals, the cubs are much more ugly than their parents. When treated with assiduity and perseverance, they may not only be tamed, but trained to fish for the supply of the table, as is practised in some parts of Sweden.

The hunting of the otter was formerly reckoned excellent sport in England; and hounds were kept solely for the purpose. The flesh of this species is eaten by the American Indians, and, on account of its *fishy* taste, occasionally by the Carthusian monks. Of the skin are made very durable gloves, which retain their softness and pliancy after being repeatedly wetted.

The *second family* of this *sub-order* is very numerous, comprising the *Felini*, whose characters are, six equal, simple, and straight cutting teeth, in each jaw; tusks strong; grinders with indented edges; claws more or less retractile; tongue covered with horny papillæ, directed backwards; iris contracted lengthways; a small cæcum; glands of the male covered with hard papillæ.

1. Genus FELIS, Lin. &c. Head rounded; muzzle short; four grinders at least on each side, in each jaw; claws quite retractile; toes united by a loose skin; no sac under the tail; five toes on the fore feet, and only four on the hind. Resident in both continents.

The animals of this genus run swiftly, and climb readily, are most ferocious hunters of their prey, which they go in search of chiefly during the night, and which they seize by surprize, lying in wait till it comes within their reach, and then suddenly springing on it at a single leap. While their prey is in sight, they frequently move their tail in a waving direction, from side to side, keeping their eyes, at the same time, steadily fixed on the object. Except from necessity, they seldom have recourse to vegetable food. As the females are considerably prolific, they have eight teats, four of which are situated on the breast, and four on the belly. This rapacious tribe lead a solitary life, never uniting for mutual defence or support, like those of the herbivorous kinds. They seek their food alone, and are often enemies to one another. Though varying in size and colour, they are nearly allied in form and disposition, being equally fierce, ravenous, and artful.

* 1. *F. leo*, Lin. &c. *Lion.* Tail long; ears plain; body pale-tawny. * 2. F. *tigris*, Lin. *Tiger.* Body marked with long dark streaks. 3. *F. pardus*, Lin. *Panther.* Upper parts marked with circular spots, and the lower with stripes. 4. *F. leopardus*, Lin. *Leopard.* Body yellow, with black spots nearly contiguous. 5. *F. uncia*, Lin. *Ounce.* Body whitish, with irregular black spots. 6. *F. onça*, Lin. *Jaguar*, or *Brazilian tiger.* Body yellowish, with black roundish and angular spots that are yellow in the middle. 7. *F. concolor*, Lin. *Conguar*, or *brown tiger.* Body tawny, and spotless. 8. *F. discolor*, Lin. *Jaguarette*, or *black tiger.* Body generally black. 9. *F. serval*, Lin. *Serval.* Tail shortish; body tawny, brown above, whitish beneath, marked with round dusky spots; orbits of the eyes white. 10. *F. jubata*, Lin. *Guépard*, or *hunting leopard.* Pale fulvous, with round black spots; tail of moderate length; neck slightly maned. 11. *F. pardalis*, Lin. *Ocelot.* Tail somewhat longish; long stripe-like spots on the upper parts, and round ones on the lower. 12. *F. tigrina*, Lin. *Margay.* Tail long; body fulvous, striped and spotted with black above, whitish beneath. * 13. *F. catus*, Lin. *Common cat.* Tail barred with dusky rings. 14. *F. rufa*, Lin. *Bay lynx.* Tail white at the tip and underneath; black banded above; body tawny, and spotted with brown; ears bearded at the tip. 15. *F. guigna*, Molina. *Guigna cat.* 16. *F. colocolla*, Mol. *Colocolla cat.* 17. *F. japanensis. Japan cat.* [The characters of these three species have not been laid down with sufficient precision.] 18. *F. yagaroundi*, Azzara. *Yagaroundi.* Fur soft, of a uniform dark-grey hue; tail bushy. 19. *F. eyra*, Azzara. *Eyra.* Body bright-tawny; whiskers white, and a small white spot on each side of the nose. * 20. *F. lynx*, Lin. *Common lynx.* Tail short; body rufous-grey, slightly spotted with black; white breast; tail black at the tip; ears terminated by long black hairs. 21. *F. montana. Mountain lynx.* Ears upright, pointed, with two brown transverse streaks. 22. *F. caracal*, Lin. *Caracal*, or *Persian lynx.* Body pale reddish brown; tail rather short; ears black externally, and tipt with long black hairs. 23. *F. canadensis*, Geoff. Body covered with long greyish hair, mingled with white, and spotted and striped with fawn-colour. 24. *F. chaus*, Lin. *Caspian lynx.* Tail moderately short, ringed towards the tip; the latter black; body brownish yellow; ears brown, and their tips bearded with black. 25. *F. abyssiniensis. Abyssinian*, or *booted lynx.* Pale reddish grey above, whitish beneath; back of the ears reddish brown.

* *F. Leo.* (Plate CCCLIV. Fig. 11, 12.) A lion of the largest size measures from eight to nine feet from the muzzle to the origin of the tail, which last is of itself about four feet long. The height of the larger specimens is four or five feet. The smallest sized are about five feet and a half long, and three and a half in height, with the tail proportionally short. The lioness, in all its dimensions, is about one-fourth less than the lion, and wants the mane.

The form and gait of this striking quadruped are bold and majestic. His head is large, his ears are rounded, his eye brows ample, his eye-balls round and fiery, and glowing, on the least irritation, with peculiar lus tre. His chest is shaggy, his tail bushy at the extremity, and a yellowish brown mane, nearly two feet long, flows on the sides of his head and neck. His predominant colour is pale-tawney, with a lighter shade, approaching to white, on the flanks and belly. The structure of his frame, and his astonishing movements, bespeak a singular combination of bones, nerves, and muscles, destined to act with wonderful effect in pursuing and destroying the creatures on which he feeds. Notwithstanding his portly dimensions, he is so far from appearing clumsy or unwieldy, that he may justly be regarded as a model of strength and activity. When provoked, he erects his mane, darts fire from his eyeballs, contracts the muscles of his cheeks and forehead into hideous wrinkles, shews his formidable teeth, and exhibits a spectacle of savage grandeur, which beggars description. His piercing eyes are furnished with a membrane which he can extend over them at pleasure. and which, perhaps, has given rise to the common opinion, that he always sleeps with his eyes open. His teeth, which are disposed like those of the cat, are extremely hard; his jaws are large and strong; the prickles of his tongue are sufficiently sharp to lacerate the skin of most animals; and the points of his terrible claws are guarded by a special provision of nature, being retractile, not into sheaths, but into the intervals between the toes, by means of an appropriate articulation of the last joint. His skeleton and internal organization nearly coincide with those of the cat. The great strength of his neck led Aristotle to suppose that it was formed of one solid bone. As he puts his mouth to the ground when he roars, the sound is equally propagated to a considerable distance on all sides, so that it is impossible to discover the precise spot whence it issues. This circumstance increasing the alarm, the intimidated animals fly backwards and forwards; and, in the dark, they often run to the very place from which the noise proceeds, and which they are so anxious to avoid.

The lion is a native of the hottest parts of Asia, but more abounds in the interior of Africa, exercising his reign over the weaker quadrupeds. According, however, to the testimony of modern travellers, his race has been much thinned in Turkey, Persia, and the Indies; and Shaw has remarked, that the Romans in one year, imported more lions for their public shows, from the single province of Lybia, than can now be found in the whole of that country.

Like the tiger and other carnivorous animals, the lion has a fetid breath. His habitation is usually in the thickest part of the forest; and he is seldom seen by day, as too much light is apt to incommode him; but, on the approach of night, he quits his den, and prowls about for prey, roaring hideously, and terrifying most of the animals within his hearing. A single stroke of his paw will break a horse's neck; the sweep of his tail will throw a strong man on the ground; and he can carry off, with apparent ease, a middle-sized ox, or even a buffalo, when lightened of its entrails. He does not openly attack any animal, unless provoked, or oppressed with hunger; but, in the latter case, he is said to fear no danger, and to be repelled by no resistance. His courage, we may remark, is exalted or depressed according to the success with which he is accustomed to employ his force. In those regions, the exclusive empire of which has been resigned to him by man, he is the most formidable of living beings. Habituated to measure his strength with that of every animal which he encounters, be becomes familiar with conquest, and, in course, haughty and intrepid. Having never experienced the power of man, instead of betraying fear of the human countenance, he disdains and defies it. Wounds irritate, but do not terrify him; nor is he dismayed at the sight of numbers. A single lion of the desert has been known to attack a whole caravan; and if, after a violent and obstinate conflict, he found himself weakened, he would retreat fighting, and still presenting his front to the enemy. But when acquainted with man, and the power of his resources, he loses his natural fortitude, and is so conscious of inferiority, that, in populous districts he has been seen to fly before women and children. His usual method of taking his prey is to spring or throw himself on it, with one vast bound, from the place of his concealment: if, however, he miss his aim, he seldom attempts another spring at the same object, but deliberately returns to the thicket in which he lay in ambush. When he siezes his victim, he knocks it down, and seldom bites it till he inflicts the mortal blow, which he generally accompanies with a tremendous roar. He seems to prefer the flesh of a Hottentot to that of a European, probably besause the former is not encumbered with clothes. The horse, next to the Hottentot, is reputed his favourite prey; and the elephant and camel are both highly relished; while the sheep, owing probably to its woolly fleece, is seldom molested. When young and active, the lion is very able to support himself by hunting down the inhabitants of the forest; and, accordingly, during this period of health and vigour, he continues in the midst of woods, far removed from human habitations, and seldom quits his haunts so long as he is able to subsist by his natural industry. But, when age prevents him from taking his lengthened springs, by which he is accustomed to secure his prey, he ventures down into more frequented spots, to make inroads on the flocks and herds, though often at the expense of his life. It is generally believed, that he devours at a meal as much as will serve him for two or three days, and that, when satiated with food, he remains in his den, till roused again by the calls of hunger or of thirst. With his strong teeth he breaks bones with the greatest ease; and he often swallows their fragments along with the flesh. When enraged, or goaded by famine, he rears his mane, and beats his tail against his back and sides, when it is extremely hazardous to approach him; but when the mane and tail are at rest, and the animal is in a placid mood, travellers may generally pass pretty near to him in perfect safety.

The duration of the lioness' pregnancy is variously stated by different writers. Ælian mentions two, and Philostratus six months; while most of the moderns allege that the period is five. From very recent observations it nevertheless appears, that the term is pretty nearly 108 days, or rather more than three months and a half. The litter usually consists of three or four, which, at birth, are somewhat larger than a half-grown cat. They are harmless and playful; and they want both the mane and the tuft at the end of the tail, till they are upwards of three years of age. They suck the dam for about twelve months, and are upwards of five years in arriving at maturity. The female, though physically weaker, and, for the most part, more timid than the male, is more ferocious than he in defence of her young; making her incursions with greater boldness, destroying every animal that falls in her way, and carrying it reeking to her offspring. When attacked in their presence, she seems to be insensible to her own wounds; and, with her head to the ground, and her eyes fixed on her assailants, she seldom fails either to save her progeny, or to perish in the conflict.

The age of the lion has not yet been ascertained with sufficient precision. Buffon, proceeding on his own data, which are by no means infallible, is inclined to limit it to twenty, or at most to twenty-two years; but it is known to have greatly exceeded this term, even when the animal lived in a state of confinement, and in a climate little congenial with its temperament; for that called Pompey, was kept in the tower of London above seventy years; and one brought from the banks of the Gambia died, in the same situation, at the age of sixty-three.

Of the noble, generous, and grateful dispositions of the lion, many tales have doubtless been related; but Mr. Barrow is disposed to believe, that, in his natural state, he is indolent, mean, and treacherous. Did our limits permit, we might easily quote several authentic instances of much docility, affection, and mildness, evinced by this species in a state of confinement. At the same time, the utmost care and attention of the keepers have sometimes failed in subduing the fierceness of others. Different individuals, in fact, of the leonine race, though apparently bred under circumstances perfectly similar, betray very different and various degrees of temper. Among those of the same litter, though reared with the same care, and by the same person, some have shewn themselves familiar and caressing, and others outrageously savage. Lions, in confinement, have occasionally bred in Europe, particularly at Naples, in the Tower of London, and in the Royal Menagerie at Paris. In the last-mentioned ample and varied collection, a lioness, of about nine years old, had thrice young; producing at the first litter nine; at the second, three; and at the third, two. The usual daily allowance of a lion in confinement, is about four pounds of raw flesh, and nearly a quart of water.

The flesh of this animal is often eaten by the negroes, and Kolben even compares it to venison; but he is said to have been partial to the flesh of beasts of prey in general; and others assure us, that that of the lion is rank and disagreeable. His skin, which was formerly a robe of distinction for heroes, is now used by the Africans as a mantle or a bed.

**F. tigris* (Plate CCCLIV. Fig. 13.) The term *tiger*, in the Armenian language, is said literally to signify an *arrow*, and denotes the rapidity with which the animal so denominated bounds or *darts* on its prey. The length of this quadruped, from the upper part of the forehead to the origin of the tail, is about nine feet, and the height about four or five feet, which is also the length of the tail. The prevailing colour of the body is a deep tawny, or orange-yellow; the face, throat, and lower part of the belly, are nearly white; and the whole is traversed by numerous long black stripes, forming a bold and striking contrast with the ground colour. The name has been vaguely applied, by various writers, to different animals of the feline tribe, as to the leopard, panther, ounce, jaguar, &c. This genuine species is a native of Asia, occurring from China and Chinese Tartary to Armenia, but chiefly frequenting the hot climates of India and the Indian Islands, particularly affecting the hilly and wooded districts; lurking in jungles and thickets, from which it issues to spread its ravages all around, attacking the flocks and herds, unterrified by the sight or resistance of man, and closing even with the lion in such fierce encounters, that the combatants have been known to fall together. When undisturbed, the tiger plunges his head into the body of his victim, and quaffs large draughts of blood, the sources of which are generally exhausted before his thirst is allayed. So prodigious, too, is his muscular strength, that he is capable of carrying off a dead buffalo, of nearly double the weight of a common ox. In his native wilds, he conceals himself from view, and springs on his prey with a most hideous roar; but, if he miss his aim, he is apt, like the lion, to shrink away, without repeating the attempt. Though he seldom makes an open attack on any creature that is capable of resistance, he seems to prefer men, when he can procure them by surprise, to any other prey. On many occasions he may be scared by fire and noise; but, when pressed with hunger, he has been known to disregard both. In China and Tartary, hundreds of travellers may be seen with lanterns carried before them, to secure them from these ravenous animals. In some parts of India, tigers are particularly fatal to woodcutters and labourers about the forests; and they have even been seen to swim out to boats at anchor, at a little distance from the shore, and drag off the men from on board. As in Java they frequently carry off travellers, when any person of consequence goes out into the country, he is attended by men who incessantly blow a sort of small French horns, the shrill sound of which is said to frighten them entirely away. The number of persons killed by tigers every year in Sumatra, is almost incredible; for there whole villages have at times been depopulated by them; whilst ideas of superstition, connected with the doctrine of transmigration, render the natives very remiss in their endeavours to destroy them. The roar of the tiger is said to be tremendous, commencing with deep, slow, and melancholy inflections, then becoming more acute, and terminating in a violent cry, interrupted by long tremulous intonations, which distract the imagination, especially when these roarings, which are uttered chiefly in the night, are reverberated by the echoes of the mountains. It has not yet been ascertained how long the tigress goes with young, but it is commonly believed to be between three and four months; and her litter usually consists of four or five. When robbed of her young, her rage knows no bounds; and, braving every danger, she will pursue the plunderer to the seashore, or into the gates of cities; and, when the hope of recovering her offspring is lost, she expresses her grief and indignation by the most fearful howlings.

Neither gentleness nor constraint has, it is alleged, hitherto succeeded in taming the full grown tiger, which seems to be scarcely sensible of the attentions of its keeper, and would equally tear the hand that feeds as that which insults or chastises it. The young, however, are not unsusceptible of a certain degree of domestication, have occasionally manifested signs of personal attachment and affection, and have lived on habits of intimacy and endearment with a dog.

The skin of the tiger is greatly prized in all the eastern countries, particularly in China, where the mandarins use it for covering their seats of justice. It is applied, moreover, to many useful or ornamental purposes. The Indian physicians attribute medical virtues to various parts of the body; and some of the inhabitants of the countries in which it occurs, eat its flesh without inconvenience or disrelish. To its fat they ascribe the virtues of a panacea; to its tongue, when dried and pulverized, the property of curing all nervous affections; and to each of its members some peculiar efficacy. Romé de L'Isle and Bomare have, strangely enough, countenanced the popular idea, that its whiskers are poisonous, and that, therefore, it always drinks in a parallel direction with the current of the river, that none of them may enter into its mouth! Gervaise, in his Natural History of Siam, had already ascribed deleterious qualities to its perspirable matter; but, as Buffon has well remarked, since it occacions so much real mischief in its lifetime, we may absolve its remains from the imputatian of imaginary evils.

* *F. Catus.* This well known quadruped occurs, both in a wild and domestic state, in Europe and Asia, and has been found unreclaimed in the two other quarters of the world. Whether all the domestic varieties have proceeded from the wild cat, or whether this last should be regarded as the common house sort, escaped into the woods, and affected by more vagrant and stubborn habits, acquired in the course of its hunting for subsistence, it would now be needless to inquire. The various points of appearance and manners in which they agree, and the facility with which they intermingle in the breeding season, may at all events convince us, that both sorts constitute but one and the same species. The wild cat, however, is much less subject to variety than the tame one, has a considerably shorter intestinal canal, and is not only larger and stronger, but has a much longer fur. The latter is generally soft and fine, of a pale yellow, blended with grey. A dusky list runs along the middle of the back from head to tail, the sides are streaked with grey, and the tail is thick, and marked with alternate bars of white and black. It is partial to hilly and wooded tracts, lives in trees, and hunts for birds, rabbits, hares, mice, rats, moles, &c. It will likewise carry off young poultry, or even tender lambs, kids, or fawns, and is the fiercest and most destructive beast of prey in this island. If only slightly wounded, it will rush on its assailant, and is not easily repelled. It sometimes attains to a very considerable size; and Bewick mentions a specimen, which measured upwards of five feet from nose to tail. In England, it was formerly reckoned among the beasts of chase; but the extension of population during the last century, the consequent reduction of forests, and the enclosure and cultivation of waste lands, have nearly extirpated the race of wild cats in the southern parts of the island. Several of the mountainous districts, however, of Ireland and Scotland, still afford them harbour in considerable numbers; and they are occasionally met with in the woods that border the lakes of Cumberland and Westmoreland. In the united parishes of Lochgoilhead and Kilmoric, in Argyllshire, they are more plentiful than foxes, making their lodging in the crevices of rocks, and in deep and narrow holes in the face of dreadful precipices, where it is exceedingly difficult to approach them, and where they produce their young.

The varieties of marking observable in the domestic cat, it would be tedious, and indeed almost impossible, to enumerate. There are, however, a few breeds so distinctly characterised, as to admit somewhat of definition. Thus the Angora variety has long silvery hair, of a silken gloss, and longest on the neck, though some of them are of a dun colour, mixed with yellow. Buffon ascribes their beautiful and luxuriant coat to the fineness of the Syrian climate, without reflecting that Angora is not in Syria, but in Asia Minor. The province of Chorazen, in Persia, produces another elegant variety, of a fine grey hue, without any admixture, and as soft and shining as silk. It is darkest on the back, and gradually softens towards the breast and belly, which are almost white. The tail is long, and covered with flowing hair, with the tip resembling a plume of feathers. The *tortoise-shell* cat is pleasingly variegated with black, white, and orange. From its frequency in Egypt, it is suppossed to have originated in that country, and subsequently to have found its way to the south of Europe. In this country it is rare, and sometimes fetches a considerable price. The Chinese cat has pendulous ears and glossy hair, variegated with black and yellow. Besides these, we may mention the *blue*, *red*, and *yellow*; the first, with blue grey hair; the second, with a red stripe from the head down the back; and the third, reddish yellow, with the head long, muzzle sharp, legs short, claws weak, and ears round and flat.

The stomach and heart in the present species, are very analogous to those of the dog; the cæcum is very small; the intestines make many convolutions; the liver is divided into five lobes; and the spleen, which is elongated, is straiter in the middle than at the extremities. It is somewhat surprising, that such a sharp-sighted naturalist as Linné should, in his summary statement of the properties and habits of the cat, have inserted the phrase, *pulices non habet*; but still more so, that it should have been allowed to stand, without comment or correction, by his editor Gmelin, and that it should have been adopted by Erxleben. *Pulices* may originally have been a slip for *pediculos*: but we may see from this, how the blunders of a great man are sanctioned and propagated. According to Dr. Darwin, cats seem to possess something like an additional sense by means of their whiskers, which have perhaps some analogy to the antennæ of insects of the lepidopterous order. These whiskers consist not only of long hairs on the upper lip, but also of four or five that stand out from each eye-brow, and two or three on each cheek, all which, when the animal erects them, make with their extremities so many points in the periphery of a circle, equal at least in extent to the circumference of any part of her body. With this instrument it is presumed, that, by a little experience, she can at once determine whether any opening among shrubs, hedges, &c. is large enough to admit her body, which to her is matter of the greatest consequence, whether pursuing or pursued. She has likewise the power of erecting and bringing forward the whiskers on the lips, which is probably for the purpose of feeling whether a dark hole be further permeable. It is commonly supposed that cats can see in the dark; and, though this is not strictly true, yet such is the peculiar structure of their eyes, that they see with much less light than most other animals, the pupil being highly susceptible of contraction and dilatation, in proportion to the degree of light by which it is affected. In the day-time it is perpetually contracted, and sometimes into a mere line; but in the twilight it resumes its natural roundness. It has also been observed, that the eyes of cats shine in the dark; and, from some experiments instituted by the Rev.

William Jones, it would appear that this phenomenon is owing to the light from within the body, which being weaker than that of the day, but stronger than that of the night, is visible only in obscurity; and the same remark probably applies to putrefying meat, fish, rotten wood, phosphorus, and the glow-worm.

In the course of their nocturnal excursions, and combats on the roofs of houses, cats are frequently exposed to fall from considerable heights; in which case they usually alight on their feet, and so escape any serious injury. Sonnini, however, who repeatedly made the experiment of throwing young cats from the window of a third floor, observes that they lay sprawling on the ground, and incapable of further movement, so that it was necessary to kill them, in order to release them from suffering. Hence he infers, that it is only when they fall accidentally, and not when they are thrown down, that they save themselves on their feet.

The fur of the cat being generally clean and dry, readily yields electrical sparks by friction, insomuch that if a dry cat be placed, in frosty weather, on a stool with glass feet, or insulated by any other means, and rubbed for a little time in contact with the wire of a coated phial, the latter will be effectually charged.

Besides rats, mice, and birds, the cat has sometimes been observed to prey on live fish; yet in general it may be remarked, that its very decided predilection for fish appears to be incompatible with its extreme aversion to wetting its feet, and seems to confirm the conjecture that it was originally destined for domestication, and therefore depends for its favourite food on the intervention of the human species.

Buffon and others have represented the cat as incapable of generous and disinterested attachment, without sufficiently reflecting, that, although less warm and steady in its affections than the dog, it is nevertheless susceptible of gratitude and kindness, and that much of its apparent caprice and ill-humour is solely attributable to the unmerited neglect with which it is too often treated. In Egypt, where it is still cherished with superstitious fondness, it is extremely gentle, and recognises its benefactor; and even in countries in which its comforts are overlooked, it is feelingly alive to those local associations which constitute a prominent feature in the human mind. More shy and wary than the dog, its good graces may yet be won by continued caresses, especially if these be bestowed on it, when it is yet young, playful, and unsuspecting. Many well authenticated facts and anecdotes, which we cannot here stop to detail, abundantly attest both the sagacity and affectionate dispositions of this much calumniated quadruped.

The female brings forth twice, and sometimes thrice, in the course of the year, concealing her kittens from the male, lest, as occasionally happens, he should devour them. Nay, she herself, by some anomaly in nature, which has never yet been satisfactorily accounted for, has been known to devour her own young the moment that she has produced them. The same phenomenon is sometimes exhibited by the sow and the rabbit. With this exception, however, which rarely occurs, the cat is a most tender and affectionate mother. If apprehensive of being disturbed, she will take up her kittens in her mouth, and remove them, one by one, to a more secure retreat. The manner in which she performs this office is worthy of remark; for she first licks them on the neck, to prepare them for being siezed by that part; she then lays hold of them with her mouth so hard as to prevent them falling out, and yet not so as to give them pain. Thus charged with her important burthen, she runs off with it in her mouth, at the same time raising her head in such a manner as not to beat it against the ground, while the little creature is so motionless as to be apparently dead. The mother, having selected a convenient spot, lays it down, forms for it a comfortable bed, and again licks it on the back. She then leaves it to fetch another, and in this way conveys the whole litter. We must all have noticed the assiduity with which she attends them, the pleasure which she manifests at their playful tricks, and the excessive grief by which she is affected at the loss of them. She has also been known to nurse with tenderness not only the young of different individuals of her own species, but even of other kinds of animals; as leverets, squirrels, and even rats.

When a kitten is first placed before a looking-glass it seems pleased and surprized, and makes several attempts at touching the reflected image. At length finding its efforts useless, it peeps behind the mirror, and expresses astonishment at the absence of the figure. It again views the image, and tries to touch it with its foot, suddenly looking at intervals behind the glass. By degrees it becomes more accurate in its observation, and begins as it were to make experiments, by stretching out its paw in different directions; and when it perceives that these motions are answered in every respect, it seems to be finally convinced of the real nature of its *other self*.

The sleep of the cat, though generally very light, is however sometimes so profound, that the animal requires to be shaken pretty briskly before it can be awakened. This particularly occurs in the depth of winter, and on the approach of snowy weather. At such periods also, as well as at some others, it diffuses a fragrant smell approaching to that of cloves. That it licks its fur, and washes its face and neck, *only* before stormy weather, is an assertion contradicted by daily experience; for this operation is performed, more or less perfectly, after every repast; but it has also been observed to be no unfrequent concomitant of sudden changes in the atmosphere, and to precede a heavy fall of rain or snow,—a circumstance which would indicate a peculiar delicacy of temperament. When at rest, and not inclined to sleep, it usually sits with the fore part of its body upright, having all the feet together, and the tail usually curved round them. Its purring is expressive of its contentment and happiness, of its affections and desires. It likewise denotes its agreeable sensations, by spreading out, and again retracting its claws, and by alternately putting down and raising its fore legs. The agitation of the tail, which in the dog is a signal of pleasure, is, on the contrary, in cats frequently a token of rage or cunning. When they run towards any object that pleases them, they generally carry their tail high and extended; and when they are inclined to play, they do not unsheath their claws, but seize the hand, or any other object, in their *velvet paws*, without scratching. The form of their teeth does not permit them readily to seize their food in their incisors, so that instead of taking provisions out of a person's hand, they prefer picking up small morsels from the ground. These they divide principally with their side teeth; and they swallow entire, all such pieces as will easily pass down the gullet.

The diseases to which the cat is incident, are little known. A sort of contagion sometimes seizes the race, and carries off great numbers of them. The cutting of their last teeth is attended with uneasiness, sickness, and languor. They are sometimes attacked by fits of vomiting, which are preceded by painful cries, accompanied by violent efforts, and frequently proving fatal. They are readily poisoned by opium, or spirit of wine; but it would appear from some observations and experiments, that they are not so easily killed by arsenic, nux vomica, or corrosive sublimate; and that their capacity of resisting the action of those highly deleterious matters, arises from the peculiar irritation of the stomach, and a tendency to inversion in the peristaltic motions, which rid them of the poison prior to the excitement of any dangerous inflammation. The general extent of their age is ten or twelve years. Sonnini, however, had a cat which lived seventeen years; and he was assured, that other persons had kept individuals of this species for twenty years or upwards.

The skins of cats form a considerable branch of the fur trade. Many are exported from Spain; but the most considerable quantity from the north, particularly from Russia, which supplies not only Europe, but China, where furs of all descriptions are in high request.

**F. Lynx.* (Plate CCCLIV Fig. 14.) The size of the lynx is about that of a moderately large dog, measuring upwards of four feet from head to tail, and the latter about six inches in length. The hair on the body is long and soft; the tail is shorter than the thighs; the legs and feet are very thick and strong; and the eyes, which are proverbially piercing, are of a pale yellow hue. We may, however, remark, that both with respect to colour and size, it is subject to many and considerable varieties in different parts of the world. By confounding it with the *caracal*, Gesner and Kolben have erroneously represented it as an inhabitant of the warmer regions of Africa, whereas it is found only in Europe, and in the north of Asia and America. It is said to be very long lived, and subsists by hunting and pursuing its prey on the tops of the highest trees, feeding on ermines, weasels, squirrels, &c. which are unable to escape from it. The lynx watches the approach of the fallow-deer, hare, and other beasts of the chase, and darts on them from the branches of trees, where it lies concealed, seizing them by the throat, and sucking their blood, after which it abandons them, and goes in quest of fresh game. Its sight is remarkably quick, and it eyes its prey at a great distance. When attacked by a dog, it lies down on its back, strikes desperately with its claws, and frequently compels its assailant to retreat. When urged by hunger, it has been known to prey on its own tribe. The female is gravid nine weeks, and brings from three to four young. As its manner of howling is similar to that of the wolf, and its skin is variegated with spots like those of a young stag, the lynx has been denominated *lupus cervarius* by some naturalists, and *loup cervier* by many of the French writers. In a state of captivity, it is extremely ferocious, frequently expressing its malignity by a snarling scream, and refusing to be tamed. Its fur is held in considerable estimation on account of its softness and warmth; and it is exported in great quantities from America and the north of Europe. In general, the further north that this article of commerce is procured, the whiter it is, and the spots are more distinct. The skin of the male, too, is more spotted than that of the female. The ancients seem to have given the name of *lynx* to an imaginary animal, which was reputed to draw the chariot of Bacchus, to penetrate with its sight the most opake bodies, and to generate gems by the concretion of its urine.

2. Genus Civetta, Geoff. Viverra, Lin. Head long; four or five grinders on each side in each jaw; claws half retractile; tongue bristling with papillæ; a sac under the anus, containing a thick and very strongly scented liquor; tail long. Resident in the hot countries of the old continent.

* 1. *C. vulgaris*, *Viverra civetta*, Lin. *Civet*, or *civet cat*. Tail spotted above, brown towards the tip; mane of a chesnut hue; back spotted with cinereous and brown. 2. *C. zibetha*, *Viverra zibetha*, Lin. *Zibet*. Tail ringed; back with grey and black waved streaks. 3. *C. genetta*, *Viverra genetta*, Lin. Tail ringed; body spotted, and blackish-tawny. 4 *C fasciata*, Geoff. *Banded civet*. Body of a deep chesnut; end of the snout, the lower jaw, and a zone passing under the eyes, of a dirty white. 5. *C. Indica*, Geoff. *Indian civet*. Form of the body much elongated; ground colour of the coat yellowish-grey; three bright brown bands across the neck. *C. fossana*, *Viverra fossana*, Lin. *Fossane*, or *fossane weasel*. Tail ringed; body cinereous, spotted with black. 7. *C. tigrina*, *Viverra tigrina*, Lin. *Tigrine weasel*, or *bizaam*. Yellowish-grey, with brown variegations; tail annulate, with a black tip; a black stripe along the back.

* *C. Vulgaris.* (Plate CCCLIV. Fig. 15.) The length from the nose to the tail is rather more than two feet; and the tail is fourteen inches. The ground colour of the body is yellowish ash-grey, marked with large blackish or dusky spots, disposed in longitudinal rows on each side, with sometimes a tinge of ferruginous intermixed. The hair is coarse, and stands up along the top of the back, so as to form a sort of mane. The body is thickish, and the nose sharp, and black at the tip; the ears are short and rounded; the eyes bright sky blue; the sides of the face, and part of the sides of the neck, of a yellowish white. Three black stripes proceed from each ear, and end at the throat and shoulders. The teeth are strong and sharp, but the claws are weak.

The civet inhabits several parts of India and Africa, where it is very prolific; yet, in more temperate regions, though it lives, and apparently enjoys perfect health, it will not breed. It is active, nimble, and voracious, feeding, like the congenerous species, on small animals, particularly on birds, which it takes by surprise, and sometimes committing depredations among poultry, when it will steal unperceived into a farm-yard. Its eyes shine in the dark; and it is probable that it can see well enough to pursue its prey during the night, as it is known to be most active at that time. It is naturally savage, and somewhat ferocious, yet may be so far tamed as to be handled without danger. Its voice is stronger than that of the cat, and has some resemblance to the cry of an enraged dog. In confinement, its favourite food is boiled meat, eggs, birds, &c. and particularly fish. It will often roll itself on its meat for a minute or two before eating.

This animal is remarkable for the production of the dung which bears its name, and which is sometimes erroneously confounded with musk. It is a secretion formed in a large double glandular receptacle, situated beneath the tail, and which the civet, by means of compressing muscles, empties spontaneously. When a sufficient time for the secrtion has been allowed, the animal is put into a long wooden cage, so narrow that the creature cannot turn itself round. This cage being opened by a small door behind, a spoon or spatula is introduced into the orifice of the pouch, carefully scraped, and its contents put into a proper vessel. This operation is performed twice or thrice a week; and the animal is said to produce most civet after being irritated; but the quantity depends also on the sort of nourishment to which it is accustomed, and the appetite with which it eats. The Dutch civet is generally less adulterated than that which is brought either from India or the Levant; and its average value in Holland may be stated at 50s. the ounce. This substance is accounted best when it is new, of a whitish colour, an unctuous consistency, and a strong disagreeable smell. It is now nearly discarded from the materia medica; while musk, ambergrease, and other drugs, have considerably diminished its reputation as a perfume.

It deserves to be remarked, that the sexes of this species are not visibly distinguished; for, in the male, nothing appears externally but three apertures, so perfectly similar to those of the female, that the difference can be ascertained only by dissection.

The *Third Family* includes the *Cynosii*, or *Canine race*, which have usually six cutting teeth placed on the same line in each jaw; tusks pretty long; grinders with denticulated margins; tongue smooth; iris contracting circularly; claws rarely retractile; cæcum very short.

1. Genus Hyæna, Cuv. *Canis*, Lin. Six cutting teeth in each jaw, of which the lateral are the largest, and, in form, pretty similar to the tusks, which last are very strong; four toes on all the feet; ears naked, long, and straight; an open slit under the tail; the hinder higher than the fore part of the body; tail furnished with long hair; a short upright mane. Resident in the hotter countries of the old continent.

* 1. *H. vulgaris*, Geoff. *Canis Hyæna*, Lin. *Common* or *Striped Hyæna*. Body ash-coloured, and marked with long black stripes, disposed in waves, from the back downwards, and crossing the legs like bars. 2. *H. crocuta*, *Canis crocuta*, Lin. *Spotted*, or *Laughing Hyæna*, or *Tiger wolf*. Reddish brown, spotted with black. 3. *H. fusca*, Geoff. *Brown Hyæna*. Brown, with slight and partial tints of greyish.

* *H. vulgaris*. (Plate CCCLIV. Fig. 16.) The hair of the striped hyæna is long, erect, rough, and coarse; the head broad and flat; and the eyes singularly expressive of sullen wildness. A bristly mane runs along the top of the back from head to tail. The tail is short and bushy, with pretty long hair, sometimes plain, and sometimes barred with black. Immediately under the tail there is an orifice, which opens into a sac or pouch, containing a substance of the consistency of civet, but of a very rank and disagreeable odour. The hyæna carries its head somewhat in the manner of a dog, when pursuing the scent, with its nose near the ground, so as to make the shoulders appear more elevated. It is about the size of a large dog or wolf, and resembles the latter both in form and disposition, but is chiefly distinguished by the great strength of its limbs, and the remarkable fulness of its black snout. Its cry is very peculiar, beginning with a moaning like that of the human voice, and ending with a hideous and violent bellowing. When first dislodged from cover, or obliged to run, it appears lame for some little time, so that a spectator would suppose one of the hind legs to be disabled; but, after running a few hundred paces, this affection wears off, and it moves fleetly forward. The neck is so extremely stiff, that, on looking behind, or on snatching obliquely at any object, it is obliged to move its whole body, somewhat in the manner of a hog. Its eyes shine in the dark, and it is supposed to see nearly as well by night as by day.

The striped hyæna inhabits Asiatic Turkey, Syria, Barbary, and many other parts of Africa. It is a wild and solitary animal, dwelling in the cavernous recesses of mountains, in the clifts of rocks, or in subterraneous dens of its own excavation. It usually lies concealed during the day, and at night roams abroad for prey. It is stronger and more daring than the wolf, and will defend itself with great obstinacy against much larger quadrupeds than itself, not shrinking from the panther or lion, and sometimes attacking the ounce, which it seldom fails to subdue. When deprived of other prey, it violates the repositories of the dead, and drags out the mangled portions of half corrupted carcasses of men and beasts. Though not gregarious from any social principle, hyænas sometimes assemble in troops, and follow, with dreadful assiduity, the movements of an army, from the hope of feasting on the slaughtered bodies. They likewise commit great devastations among flocks and herds, and will even make nightly incursions into the villages, and carry off with them whatever they are able to master. The enclosures round houses do not always protect dogs and asses from their savage attacks; nor does the sight of man, or the report of fire arms, deter them from prowling about a dead camel or other carcass.

With all its fierceness and malignity of disposition, instances are not wanting of the hyæna having been rendered tame, although the contrary position has been repeatedly asserted.

The ancients entertained many absurd notions relative to this quadruped, such as, that its neck consisted of one jointless bone; that it annually changed its sex; that it could by incantation, rivet shepherds and shepherdesses to the spot on which they stood, &c.

2. Genus Fennecus, Desmar. Snout elongated; claws short, half retractile; ears remarkably large, and naked externally, or, at most, covered with very short hairs; tail slightly bushy.

1. * *F. Arabicus*, Desmar. *Canis cerdo*, Lin. *Cerdo*, *Zerda*, or *Fennec*. (Plate CCCLV. Fig. 17.)

This beautiful little animal is about ten inches long, and of a yellowish white colour. Its eyes are large, and of a bright black; its ears are of an uncommon size, internally of a bright roseate hue, and edged with a broad margin of white hair, with an orifice so small as to be scarcely perceptible. Its legs and feet are shaped like those of a dog, and its tail is long, tapering, and tipt with black. It inhabits the vast deserts of Zaara, that extend beyond Mount Atlas; and is said to be called by the Moors, *zerda*, though Mr. Bruce, who saw it often, and who has given an interesting account of its appearance and manners, says that its proper name is *fennec*. It feeds on insects, especially locusts, sits on its rump, haunts the top of palm trees, barks like a dog, though with a shriller voice, is very vigilant, and so swift, that it is very rarely taken alive. Mr. Bruce's favourite specimen ate greedily of dates, or any sweet fruit, the eggs of small birds, bread, honey, sugar, &c. "He had," continues the celebrated traveller, "a very sly and wily appearance. But as he is a solitary animal, and not gregarious, as he has no particular mark of feelings about him, no shift or particular cunning which might occasion Solomon to qualify him as wise, as he builds his nest upon trees, and not on the rock, he cannot be the saphan (or *coney*) of the Scriptures, as some, both Jews and Arabians, not sufficiently attentive to the qualities attributed to that animal, have, nevertheless, erroneously imagined."

From the discordant accounts of different writers, we are tempted to suspect that the *cerdo* and *fennec* may ultimately be found to be distinct species, of which the former may be more nearly allied to the canine tribe, and the latter to the family of squirrels.

3. Genus CANIS, Lin. &c. The head flat on the crown, with a lengthened snout. The claws are long, a little curved, and not retractile. The females produce many young at a litter, and have generally ten teats. They form a carnivorous race, tearing what they devour, but capable, when urged by necessity, of subsisting on vegetable food. In their native wilds, they frequently associate in numerous packs, which are often sufficiently powerful to make war with, and overcome many beasts of prey that are, individually, much stronger and more ferocious than themselves. Their rapacity exceeds all bounds; flocks and herds have been swept before them; and, from the attacks of some of the more formidable species, even men themselves have not, in all cases, been able to effect their escape. Their habitations are burrows or dens, which they scratch in the ground, or which they find ready formed in the clefts of rocks, or the deep recesses of forests. In these they generally sleep during the day, issuing, at the close of evening, to prowl about for plunder. Many of them are extremely disgusting in their feeding, preferring bodies which they happen to find exposed, or which they are enabled to unearth, to fresh and recently killed food. They thus, however, contribute, especially in hot countries, to the health of the human race, by preventing the air from being loaded with noxious effluvia, generated from carcasses that would otherwise be left to rot on the soil, and to scatter around them disease and death. The young are blind, and, in other respects, not quite formed at birth. Most of them attain to their full size, and arrive at maturity in about two years; and the general duration of their life seems to be between fourteen and twenty years.

* 1. *C. familiaris*, Lin. &c. *Familiar*, or *common dog*. Tail recurved, and turned towards the left. * 2. *C. lupus*, Lin. &c. *Wolf*. Tail bent inwards, and hanging down. 3. *C. lycaon*, Lin. *Black wolf*. Tail straight. * 4. *C. vulpes*, Lin. &c. *Fox*. Tail straight; tipped with white. 5. *C. alopex*, Lin. *Brant-fox*. Tail straight, and tipped with black. * 6. *C. lagopus*, Lin. *Isatis*, or *Arctic fox*. Tail straight; feet covered with thick fur. * 7. *C. aureus*, Lin. *Jackall*. Pale fulvous, with straight tail. 8. *C. mesomelas*, Lin. *Cape jackall*. Ferruginous, with straight tail, and black dorsal band. 9. *C. tricolor*, Geoff. *Three-coloured fox*. Cinereous above; white beneath; a cinnamon coloured band along the flanks. 10. *C. Virginianus*, Lin. *Virginian fox*. Whitish grey, with straight tail. 11. *C. decussatus*, Geoff. *C. cinereo-argenteus*, Lin. *Fulvous-necked fox*. Ash-grey, with straight tail, and the sides of the neck fulvous. 12. *C. argentatus*, Geoff. and Lin. *Silvery fox*. Deep brown, or black, with longer hairs of a silvery white. 13. *C. antarcticus*, Geoff. and Lin. *Antarctic fox*. Cinereous brown; villous; tail tipt with white. 14. *C. cancrivorus*, Geoff. *Cancrivorous fox*. Upper parts of the body of the colour of the common hare; the under parts of a dim white, bordering on fawn; hind legs black; fore legs deep brown. 15. *C. culpæus*, Molina and Desmar. *Culpeu fox*. Deep brown; tail straight, long, and covered with short hair, like that of a dog. 16 *C. ægyptius*, Geoff. *Egyptian fox*. Yellowish; ears black. 17. *C. Corsac*, Lin. *Corsac fox*. Tail straight, fulvous, with the base and tip white. 18. *C. karagan*, Lin. *Karagan fox*. Tail straight; body grey; and ears black. 19. *C. Barbarus*, Lin. *Barbary jackall*. Pale brown, with straight tail; a black descending forked band behind each ear; and three dusky bands on the tail. 20. *C. Ceilonicus*, Lin. *Ceylonese dog*. Yellowish-grey; with lengthened snout; long sharp pointed tail; and crooked claws. 21. *C. thous*, Lin. *Surinam dog*. Greyish above; white beneath; tail reflected. 22. *C. mexicanus*, Lin. *Mexican wolf*. Ash-coloured, and variegated with dusky bands and fulvous spots; tail deflected. 23. *C. fuliginosus*, *Sooty fox*. Of a fuliginous hue, with straight tail.

* *C. familiaris*. See DOG.

* *C. lupus*. (Plate CCCLV. Fig. 18.) The wolf is usually of a pale grey colour, with a cast of yellowish, but varies considerably in its shadings in different parts of the world: thus, some in France and Germany are yellow; many of those in Russia are white; such as inhabit Canada are often black; and those from the Cape of Good Hope are grey striped with black.

Though, in appearance and habits, nearly related to the dog, the wolf is distinguished by its superior size, its more muscular and robust body, and the greater breadth of the upper part of the face; at the same time that its whole form is longer, and the oblique position of its eyes, the green colour of its eye-balls, and its coarser coat, give it an air of greater fierceness. Its internal structure is perfectly analogous to that of the dog; and from the union of the two species, a fertile offspring has been occasionally produced.

The wolf occurs in almost every temperate and cold climate in the world. It is endued with great strength, especially in the fore parts of the body, and in the muscles of the neck and jaws, so that it can bear away a sheep in its mouth, and yet outstrip the shepherd. It bites fiercely, especially when its victim is incapable of making resistance; for it is wary, and even timid with a formidable adversary. It has a quick ear, a penetrating eye, and, above all, an exqusite sense of smell; for it scents carnage at the distance of a league, and traces living animals, though removed from it by a long interval. It issues from the forest on the windward side, and halts about the outskirts to receive the effluvia of living or dead bodies. As, in default of better fare, it greedily devours the most putrid carcasses, or any garbage that chance may throw in its way, its smell is extremely offensive. It is capable of supporting long abstinence, and will sometimes swallow earth or mud, to relieve the uneasy sensations of hunger; but when these sensations become imperious, it is ravenous and desperate, and will attack children, women, and even men. Such of them as have once tasted human flesh seem to give it the preference to every other, will attack the shepherd rather than the flock, and will hover in the rear of armies, to glut themselves with the blood of the slain.

When satiated with food, or fatigued with running, the wolf indulges in a light sleep, though more commonly during the day than in the night. It drinks frequently, and, if regularly supplied with water, is capable of fasting four or five days. The female breeds only once a year, goes about three months and a half with young, brings from three to nine at a litter, suckles them for some weeks, teaches them to eat flesh by chewing it before she presents it to them, then fetches them field-mice, leverets, partridges, chickens, &c. which she shares among them, and, lastly, trains them to cater for themselves; all which is accomplished in the course of ten or twelve months. Should they be threatened with an attack, she defends them with great intrepedity; though, on other occasions, she is rather timid. The young attain their full growth in their third year; the old animals become grey, and seldom live more than fifteen or twenty years.

In the populous districts of North America, the numbers of wolves have been greatly reduced; and, in this island, the race has been long since extirpated. In the polar regions wolves sometimes get on the ice of the sea during the spring, in pursuit of young seals, which they catch asleep; but when the ice separates, and carries them to a distance from the shore, they are heard howling in a dreadful manner, and almost infallibly perish.

Notwithstanding its savage nature, the wolf is still susceptible, when taken young, of a certain degree of domestication. In the east, particularly in Persia, it is taught to dance, wrestle, and perform various feats for the amusement of the people. It is sometimes affected with madness, attended with similar appearances to those which are exhibited in that state by the dog, and productive of the same symptoms in consequence of its bite.

"There is nothing of worth belonging to this animal," says Buffon, "but his skin, which is manufactured into coarse, but warm and durable furs. His flesh is nauseous to every other animal, and the wolf alone willingly eats of the wolf."

* *C. vulpes.* The fox, which, in numerous varieties of colour, and gradations of size, occurs in all the northern and temperate regions of the globe, has a broad head, a sharp snout, a flat forehead, eyes obliquely seated, ears sharp and erect, a body well covered with hair, and a straight, bushy, and somewhat pointed tail. Its predominant colour is yellowish-red, or yellowish-brown; a little mixed with white or ash-colour on the forehead, shoulders, hind part of the back, and outside of the hind legs. The breast and belly are cinereous-grey, or whitish-grey; the tips of the ears and the feet are black; the head is larger than that of the dog, in proportion to the size of the body; the ears are shorter; the tail much larger; the hair longer; and the eyes are more oblique. The intestines too, particularly the cæcum, are more capacious; and the cutting teeth of the upper jaw have no lines or furrows, like those of the dog and wolf. Another mark of distinction is its smell, which is very strong and offensive, being analogous to that of the bruised root of crown-imperial. It utters a yelping kind of bark, consisting of a succession of similar tones, concluding with an elevation of the voice, and frequently heard during winter, but not in the summer. Lastly, in dispositions it differs from the dog; for it is tamed with difficulty, is never completely reclaimed, and is a stranger to the exercise of generosity and kindness. Notwithstanding these points of discrepancy, however, between the fox and the dog, and notwithstanding the experiments of Buffon, which were instituted on individuals in a state of confinement, it is a well-known fact, that the two species will occasionally breed, and produce a mongrel race.

The fox, we need scarcely mention, has been proverbially celebrated for his cunning; and, although this feature in his character has given rise to much exaggeration and fable, his proceedings are more under the guidance of craft and subtlety, than of courage, or the spirit of enterprize. He chooses his habitation in brakes, woods, or coppices, preparing his bed under hard ground, the roots of trees, or similar situations, where he can contrive proper outlets to escape from danger. He does not always take the trouble of making a hole for himself, but often procures accommodation by dispossessing the badger. His lodge is seldom remote from the habitations of man, and often in the neighbourhood of some farm-yard or village. He listens to the crowing of the cocks, and the cries of the poultry, scents them at a distance, selects his time with judgment, conceals his road as well as his purpose, slips forward with caution, sometimes even trailing his body, and seldom makes a fruitless expedition. If he can either leap over the wall, or creep in underneath, he ravages the court-yard, puts all to death, and retires softly with his prey, which he conceals under herbage, or carries off to his kennel. In a few minutes he returns for more, which he bears away or conceals in the same manner, but in a different place. In this way he proceeds systematically, till the progress of the sun, or some movement perceived in the house, warns him that it is time to suspend his operations, and to retire to his den. He visits, very early in the morning, the nets and bird-lime of the fowler, removing, in succession, the birds that happen to be entangled, hiding them in different places, where he perfectly well knows where to find them, even at an interval of some days. He hunts young hares in the plains, seizes old ones in their forms, digs out rabbits from the warren, detects the nests of quails and partridges, seizes the mothers on their eggs, and destroys a great quantity of game. In procuring young rabbits from their burrows, he follows their scent above ground, till he comes to the end where they lie, and then, scratching up the earth, descends on them, and despatches them. In default of other victims, he makes war on rats, field-mice, serpents, lizards, toads, and moles, of which he consumes great numbers, and with which, like the cat, he plays before he devours them. When urged by hunger, he will also eat insects, or roots; and, if near the sea-coast, will seize on crabs, shrimps, or shell-fish. He manifests a predeliction for grapes and other sweet fruits, and will boldly attack wild bees, to get at their stores. Assailed by the hosts which fasten on him with their stings, he retires, but only for a few minutes, rids himself of his opponents, by rolling on the ground, and crushing all that stick to him, and then returns to the charge, and devours both wax and honey. Though sated with food, his active foresight will often prompt him to prolong his researches, less with the intention of discovering fresh booty than of exploring the details of his future resources. Thus, he frequently returns to the various holes which he had at first cleaned, surveys them with much precaution, enters into them and slily examines their different issues. With cautious slowness he approaches objects that are new to him, and which, on account of their novelty, excite his suspicion and distrust. A favourite lure will ensnare him in the days of his inexperience, but, when apprised of its nature, the same expedient becomes unavailing. He seems to smell the very iron of the trap, and carefully shuns it.

If he perceive that the means of ambush are multiplying around him, he quits his place of residence, and retires into some more secure quarters. Man, with all his reasoning and machines, requires himself much experience not to be over-reached by the prudence and stratagems of this wily quadruped. If all the issues of the kennel are beset with snares, the occupant scents and recognizes them, and, rather than fall into them, exposes himself to the most cruel and protracted privation of food. This state of alarm in confinement is neither mechanical nor passive ; for he leaves nothing untried to escape from danger ; and, when a claw remains, he works at a new path, by which he often eludes the menaced ruin. In the fox, in short, as in the wolf, we may remark an aptitude to acquire habits, and to be regulated by his reflections on existing circumstances. Where no war is waged against him, he is comparatively ignorant and careless of his conduct ; but where the apprehension of pain or death, exhibited under various forms, has produced multiplied sensations, which become fixed in his memory, and give rise to comparisons, judgments, and inductions, he acquires skill, penetration, and cunning. If the imprudence and thoughtlessness of youth frequently make him deviate from the right path, the experience of age corrects his wanderings, and teaches him to discriminate true from false appearances.

The fox sleeps much during the day, lying, like the dog, in a round form. In clear and very warm weather, he may sometimes be seen basking in the sun, or amusing himself with his fine bushy tail. Crows, magpies, and other birds, which justly consider him as their common enemy, will often give notice of his presence by the most clamorous notes, and follow him a long way from tree to tree, repeating their outcries.

The females of this species produce only once a-year, and have from three to six young at a time. If the dam perceive the place of their retreat to be discovered, she carries off her cubs, one by one, to a more secure habitation. The young are brought forth blind, and continue growing for about eighteen months.

It is almost superfluous to mention, that fox-hunting is a favourite diversion with many of the nobility and gentry of this country, and that it is more zealously and successfully prosecuted in England than in any country in the world. When the fox finds himself pursued, he generally makes towards his hole, and, penetrating to the bottom, lies till a terrier is sent in to him. If his den happens to be under a rock, or the roots of trees, the terrier is no match for him, and he cannot be dug out by his enemies. When the retreat to his kennel is cut off, his stratagems and shiftings are as surprising as they are various ; for he betakes himself to the woody parts of the country, and prefers the paths that are most embarrassed with thorns and briars. He runs in a direct line before the hounds ; and, if hard pushed, resorts to the low wet grounds, as if conscious that, in such situations, the scent is with more difficulty traced. When overtaken, he becomes obstinately desperate, turns on his adversary, and defends himself to the last gasp. The severest blows will not make him quit his hold ; and he fights in silence until torn in pieces. Both dogs and horses, particularly the latter, have frequently fallen victims to the ardour of the chase, which has sometimes continued for eight or ten hours, almost at full speed, and for a distance of fifty miles, without the smallest interruption.

The skin of the fox is furnished with a soft and warm fur, which, in many parts of Europe, is used for muffs and lining of clothes. On this account vast numbers of foxes are taken in the Vallais, and the alpine districts of of Switzerland ; insomuch, that a Lausanne furrier is sometimes in possession of two or three thousand skins, all procured in the course of a single winter. Great numbers are likewise imported from Hudson's Bay, Newfoundland, &c. The natives of the former country eat the fox's flesh, notwithstanding its rank flavour ; and even the inhabitants of some parts of the continent of Europe have recourse to it, during the vintage, when the animals are fattened with the grapes.

* *C. lagopus.* This quadruped is inferior in size to the preceding, and is of a bluish grey colour, and sometimes white. It occurs only in the arctic regions, a few degrees within and without the polar circle, particularly in Kamtschatka, and all the countries bordering on the northern ocean. It is so very hardy as to prowl about for prey during the utmost rigour of the hyperborean winter. It subsists on young wild-geese, and all kinds of water-fowl and their eggs, on hares, the smaller quadrupeds, &c. and frequently, from necessity, on wild berries, shell-fish, or other substances rejected by the sea. In some regions they burrow in the earth, and form holes many feet in length, strewing the bottom with moss ; but, in Greenland and Spitzbergen, where the ground is seldom quite free from frost, they live in the clefts of rocks, two or three inhabiting the same hole. Being good swimmers, they often cross from island to island in quest of prey. For the sake of their skins, which furnish a light and warm, but not a durable fur, they are caught in pit-falls, springs, or traps, baited with capelin, or a bit of flesh. By far the most interesting account which we have met with of the manners of this species, is that detailed by Steller : but we can afford room only for a part of the passage to which we allude.

" When we made a halt to rest by the way, they gathered around us, and played us a thousand tricks in our view; and when we sat still, they approached us so closely that they gnawed our shoe-strings. If we lay down, as if intending to sleep, they came and smelt at our noses, to ascertain whether we were dead or alive. On our first arrival, they bit off the noses, fingers, and toes of our dead, when we were preparing the grave ; and thronged in such a manner about the infirm and sick, that it was with difficulty we could keep them off.

" Every morning we saw these audacious animals patrolling among the sea-lions and polar bears lying on the strand, smelling at such as were asleep, to discover whether some one of them might not be dead. If that happened to be the case, they proceeded to dissect him immediately ; and soon afterwards, all were at work in dragging the parts away. As the sea-lions, in their sleep, sometimes overlay their young, the foxes, every morning, examined the whole herd of them, one by one, as if conscious of this circumstance, and immediately dragged away the dead cubs from their dams.

" As they would not suffer us to be at rest by night or day, we became exasperated against them, young and old, and harrassed them by every mean we could devise. When we awoke in the morning, there always lay two or three that had been knocked on the head the preceding night ; and I can safely affirm, that, during my stay on the island, I killed above two hundred of these animals with my own hands. On the third day after my arrival, I knocked down with a club, within the space of three hours, upwards of seventy of them, and made a covering to my hut with their skins. They were so numerous, that, with one hand, one could hold to them a piece of flesh, and knock them down with a stick or axe in the other.

"From all the circumstances that occurred during our stay, it was evident that these animals could never before have been acquainted with mankind, and that the dread of man is not innate in brutes, but must be grounded on long experience.

"Like the common foxes, they were the most sleek and full of hair in the months of October and November; in January and February it was over-thick; in April and May they began to shed their coat; in the two following months they had only wool on them, and appeared as if they went in waistcoats. In June they dropped their cubs, nine or ten at a brood, in holes or clefts of the rocks. They are so fond of their young, that, to scare us away from them, they barked and yelled like dogs, by which they betrayed their covert. But no sooner did they perceive that their retreat was discovered, than (unless they were prevented) they dragged the young away in their mouths, and endeavoured to conceal them in some more secret place. On one of us killing the young, the dam would follow us with dreadful howlings, by night and day, for a hundred versts or more, and would not even then cease till she had done her enemy some material injury, or was herself killed by him.

* *C. aureus.* (Plate CCCLV. Fig. 19.) The jackall is larger, and stands higher on its legs than the fox. The head is of a fox-red above, blended with cinereous grey hairs, which have each a blackish ring and tip. The upper lip is white on each side of the nose, and the throat is of the same colour. The whiskers, the long hairs on the chin, and those above the eyes, which are five in number, are black. The ears are fox-red externally, and white internally: the neck and back are all over grey-yellow; and both, but especially the latter, are dashed with a shade of dusky, owing to the tips of the long hairs on these parts. Behind the neck, and on the back, is a large marking of dark grey, in the form of a lancet, with the point turned toward the animal's tail. The under parts of the body and the legs are of a light reddish yellow, but the shoulders and thighs are externally of a fox-red. The tail is straight, somewhat longer and more hairy than that of the wolf, of a greyish yellow, but more inclining to fox-red, toward the extremity. The length of the body is about thirty inches, and of the tail eleven. The female is somewhat smaller than the male, and has six or eight teats.

We have been thus minute in our delineation of the jackall, because, though very generally diffused in Asia, and in many extensive districts of Africa, it has nevertheless been described, by different naturalists and travellers, in very vague and even contradictory language. It likewise deserves our particular notice on another account, namely, because Guldenstaed and Pennant have been induced to represent it as the genuine source of all the varieties of the canine species. With the latter it certainly has some close and intimate affinities, such as a disposition to associate with mankind; and, when taken young and domesticated, to evince attachment to individuals. In this state, these animals love to be fondled and patted with the hand, and, when called by name, will leap on a table or a chair. They drink by lapping, eat readily from the hand, are fond of bread, and delight in playing with dogs. Mr. Hunter has, moreover, related the circumstance of a female jackall, taken on board an East Indiaman at Bombay, whilst a cub, and being impregnated by a dog during the voyage. Of the six puppies resulting from this union, one afterwards produced young from intercourse with a dog. From this, and other recently observed facts, it should seem that the fox, the wolf, the jackall, and the dog, are all nearly related to one another, and that the jackall is more intimately connected with the dog than either of the other two. But still we may remark, that it is distinguished from it by permanent external characters, and that its domestication is never so complete as that of the dog. Buffon even accuses it of stupidity, and of an untractable temper.

In their natural state, jackalls associate in packs, which vary in number, from about forty or fifty to two hundred; and they hunt, during the night, in full cry, the gazelle, and other animals of the antelope tribe. They devour poultry and lambs, ravage the streets of villages, and gardens near towns, and are even said to destroy unprotected children. If fresh animal prey is not to be met with, they will feed on roots, fruits, or the most infected carrion; for they greedily disinter the dead, and shrink not from consuming the most putrid bodies. Their howlings in the night are loud and hideous; for, when one commences, the whole troop exert their lungs, and join in one general yell. All the beasts of the forest are roused by the clamour; and the lion, and other predacious animals, receiving it as a signal for the chase, pursue such timid creatures as fly from the noise. From this circumstance it is, that the jackall has been termed the *lion's provider.* In the daytime the jackalls are silent, and generally conceal themselves in holes or dens. When they meet with travellers, they stop to reconnoitre them, without any symptoms of fear. As a proof of their extreme voracity, we may mention, that, for want of better fare, they will eat even the leather of harnessing, or old boots and shoes.

The females breed once a-year, are gravid one month, and bring from five to eight at a birth.

IV. Sub-order. Pedimana.

Thumbs separate, or wanting on the hind feet only; grinding teeth with sharp prominences; marsupial bones in both sexes; most frequently a pouch, or simple longitudinal duplication of the skin of the belly in the females; complete clavicles; a cæcum and large intestine; the penis of the male, and the vagina and the clitus of the female, with a bifurcation; teats inguinal, and situated in the pouch or doubling of the skin.

1. Genus Sarigua, Desmar. Didelphis, Lin. Ten superior, eight inferior cutting teeth, of which the intermediate are the broadest and shortest; tusks long and pointed; thumb of the hind feet separated, and destitute of a claw; the other toes of an equal length, and either free or palmated, and furnished with strong, but not very pointed claws; tail long, naked, and prehensile; external ears pretty large; tongue ciliated in the margin; sole of the foot resting on the ground. In the three first of the species which we have to particularize, the females are furnished with a real pouch for the reception of their young, and in the remaining six, with a mere folding of the skin for the same purpose.

1. *S. marsupialis*, *Didelphis marsupialis*, and *cancrivora*, Lin. *Amboyna*, or *Molucca opossum*. Eight teats within the pouch. 2. *S. Virginiana*, *Didelpeis Virgini-*

ana, Pennant and Geoff. *Long-haired opossum.* Body covered with long brown hair; head white, with a brown spot. * 3. *S. opossum*, *Didelphis opossum*, Lin. *Common* or *Virginian opossum.* Half of the tail hairy; a light coloured spot above the eyes. 4. *S. murina*, *Didelphis murina*, Lin. *Murine opossum*, or *marmose.* Tail hairy at the base. 5. *S. cayopollin*, *Didelphis cayopollin*, and *dorsigera*, Lin. *Mexican*, or *Merian opossum.* Tail longer than the body, margin of the orbits black. 6. *S. brachyura*, *Didelphis brachyura*, Lin. *Short-tailed opossum.* Tail short; ears naked; body rufous. 7. *S. memmima*, *Didelphis memmima*, Cuv. *Yapoch*, or *Little otter of Guiana.* Tail hairy above, naked beneath, and nearly as long as the body. 8. *S. crassicaudata. Thick-tailed opossum.* Tail large and strong; upper parts of the body of a bright cinnamon hue, the under parts of a bright grey. 9. *S. pusilla*, *Didelphis pusilla*, Desmar. *Dwarf opossum.* Body of a leaden hue, and whitish underneath.

**S. opossum.* (Plate CCCLV. Fig. 20.) This species is about the size of a small cat, though, from the upright growth of its fur, it appears to be a good deal thicker. Its general colour is dingy white. The head is long and pointed; the mouth wide: the tail about a foot long, hairy at the origin, but further down covered with a scaly skin. The legs are short and blackish. The female is furnished with a large cavity, or receptacle, which can be opened and closed at pleasure, and in which the young, immediately after birth, are either placed by the parent animal, or instinctively lodge themselves. In this asylum they have easy and constant access to the teats, and are transported by the dam from place to place. Two bones placed before the *os pubis*, and joined to it as their base, support and serve to fix the muscles which are employin opening the pouch. To these muscles there are antagonists, which serve in the same manner to shut it; and this office they perform so exactly that, in the living animal, the opening can scarcely be discerned, except when the sides are forcibly drawn asunder. When the young have attained sufficient growth and strength, they issue from their retreat; but will occasionally betake themselves to it again on the appearance of danger, when the parent carries them about with every symptom of the most tender affection.

When the female is about to litter, she chooses a place in the thickest bushes, at the foot of some tree, and, aided by the male, collects a quantity of fine grass, which she forms into a sort of rude nest, and in which she produces from four to six young ones at a time.

As the conformation of its fore feet prevents it from either running or walking very fast, the common opossum appears to be very helpless. In recompense, however, for this apparent defect, it is able to climb trees with the utmost facility and expedition, and with more activity than most quadrupeds. It eagerly hunts after birds and their nests, and is very destructive of poultry, whose blood it sucks without eating the flesh. It also eats roots and wild fruits. When pursued and overtaken, it will feign itself dead till the danger is over; and, if we may implicitly believe the account of Du Pratz, it will not, when seized in this condition, exhibit any signs of life, though even placed on a red hot iron; and, when there are any young in the pouch of a female, she will rather suffer both herself and them to be roasted alive than give them up. These creatures never move till either their assailant is gone to a distance, or has concealed himself, when they endeavour to scramble, with all possible expedition, into some hole or bush. From their extraordinary tenacity of life, it is a common saying in North Carolina, that "if a cat has nine lives, the opossum has nineteen." They are of gentle dispositions, and easily tamed; but their smell is disagreeable, and their voice is a sort of grunting squeak. The flesh, which is white and well-flavoured, is preferred by the Indians to pork; and that of the young eats very much like a sucking pig.

2. Genus Dasyurus, Geoff. Snout very pointed; lower jaw shorter than the upper; eight upper, six lower cutting teeth; tusks of a middle size; tail long and bushy; no pouch under the belly of the female; no thumb on the hind feet; external ears pretty long and naked; body slender. Resident in New Holland.

1. *D. maculatus*, or *spotted opossum.* The characters correspond with those of the genus. The *guttatus* of Desmarest seems only to be the female of this species, or an accidental variety.

3. Genus Wombatus, Geoff. Head large and flat; six cutting teeth in each jaw; two tusks and sixteen grinders; body squat; legs short; hinder thumb not very conspicuous; claws very strong; the mere rudiments of a tail; external ears very short. Resident in New Holland.

* 1. *W. fossor*, Desmar. *Digging wombat.* (Plate CCCLV. Fig. 21.) Its length from the tip of the nose to that of the tail is 2 feet 7 inches, of which the body measures 1 foot 11 inches. The head is about 7 inches, and the tail only five-tenths of an inch. The circumference behind the fore legs is 27 inches, and round the thickest part 31 inches. The weight is from 25 to 30 pounds. The hair is coarse, thinly set on the belly, thicker on the back and head, and thickest on the rump and loins; of a light sandy brown tinge, varying in its shades, but darkest along the back. The hair on the face lies in regular order as if it were combed, with its eyes diverging from the nose. In size the male and female are nearly similar; but the latter is perhaps rather the heaviest.

This animal has a slow hobbling pace, and is generally of a mild and gentle disposition, but bites hard, and is furious when provoked. It inhabits Fourneaux's Island, and the mountains to the west of Port Jackson. It lives under ground, and is admirably formed for burrowing. According to the account given of it by the natives, the wombat of the mountains is never seen during the day, whereas that of the islands feeds in the day-time, and principally on grass; so that probably there are at least two species of this genus. A male individual was, by Mr. Brown the naturalist, transmitted to the care of Sir Everard Home, and lived in a domestic state for two years. It burrowed in the ground whenever it had an opportunity, and covered itself in the earth with surprising quickness. It was quiet during the day, but constantly in motion during the night; was very sensible to cold; ate all kinds of vegetables; but was particularly fond of new hay, which it dispatched stalk by stalk, taking it into its mouth like a beaver by small bits at a time. It was deficient in sagacity, and appeared to be attached to those to whom it was accustomed, and who treated it with kindness.

Sir Everard describes what he conceives to be another species of wombat, and which seems to haunt the branches of the loftiest gum trees.

4. Genus Phalanger, La Cépède; Phalangista,

Geoff.; Didelphis, Lin. Head broad and flat; the teeth and toes as in those of the genus immediately succeeding; tail long, bushy, not prehensile; skin of the sides extended between the four limbs, and contributing to flight; a pouch under the belly of the female; ears very short; cæcum very large. Resident in the East Indies and New Holland.

* 1. *P. volans*, *Didelphis volans*, Cuv. *Didelphis petaurus*, Lin. *Petaurine*, or *great flying opossum of New Holland*. Blackish grey, tinged with ferruginous, whitish beneath. 2. *P. sciureus*, *Didelphis sciurea*, Lin. *Squirrel opossum*. Pale grey above, snow-white beneath.

* 1. *P. volans*. (Plate CCCLV. Fig. 22.) The body is about the size of a full grown cat, or a small rabbit, and the general appearance of the animal is similar to that of a flying squirrel. By the extension of the loose skin of the sides and belly, when it stretches out its legs, the surface of its body is increased, and the creature is enabled to keep itself buoyant in the air, until the projectile force of its leap is exhausted, when it naturally descends. Thus it is capable of darting from tree to tree, and over a space of nearly a hundred yards; but it always ascends to the top of a tree before it takes its leap.

5. Genus Cæscoes, La Cépède; Phalanger, Cuv. Didelphis, Lin. Head broad and flat; six cutting and six canine teeth in the upper jaw; two long flat cutting teeth projecting forward, or three very small tusks on each side in the under jaw; ten tuberculated grinders in each jaw; two or three toes of the hind feet united to the claw, and shorter than the others; thumbs separate, and without claws; no flying membrane; external ears very short; cæcum very large; clavicle short and strong; an abdominal pouch in the female; tail prehensile. Resident in the islands of the Indian seas.

1. *C. Amboinensis*, La Cépède; *Didelphis orientalis*, Lin. *Oriental opossum*, or *phalanger*. - Rusty white beneath, with a black dorsal line; tail as long as the body, and hairy to near the middle.

SECOND DIVISION.

Absence of at least one description of teeth.

ORDER IV. RODENTIA.

No canine teeth, except in the first genus, which has been retained in this division on account of its close affinity with the kanguroo; cutting teeth separated from the grinders by a vacant space; grinders most frequently with blunted prominences, having their crown somewhat flat, and formed of transverse laminæ, rarely furnished with sharp points; intestines very long; cæcum very capacious; clavicles frequently entire; sometimes an abdominal pouch; claws crooked, and not retractile; thumb of the hind feet separated only in two species. This order has been conveniently distributed into four sections.

Section I.

A. More than two cutting teeth in the upper jaw; sometimes tusks in the upper jaw; ten grinders, with transverse ridges in each jaw; an abdominal pouch in the females, for the reception of the young at birth; the hind quarter much longer than the fore; hind legs very long, resting wholly on the ground; four toes on the hind, and five on the fore feet; tail hairy, very thick, not prehensile, and occasionally serving the purpose of an additional hind foot; clavicles very short. Resident in New Holland.

1. Genus Potorus, Desmar. Kangurus, Cuv. and Geoff. Macropus, Lin. Six cutting teeth in the upper jaw, of which the two intermediate project; two tusks in the lower jaw; hind legs long; four toes on the feet, of which the two innermost are united to the base of the claws; tail strong and pointed; ears pretty short, and whiskers small.

* 1. *P. murinus*, Geoff. *Macropus minor*, Lin. *Lesser Kanguroo*, *rat kanguroo*, or *kanguroo rat*. Brown above, ash-coloured below. In general shape it much resembles the kanguroo; but it is much smaller, less elegant and pleasing, covered with a coarser hair, and has the head somewhat flattened sideways, and resembling that of a rat. Its manners are little known; but they are supposed to be analogous to those of the kanguroo.

2. Genus Kangurus, Cuv. and Geoff. Didelphis, Lin. Six flat equal cutting teeth in the upper jaw, two very large, and projecting in the lower jaw; no tusks in the upper jaw; four toes on the hind feet, the two innermost very small, and united to the base of the claws; tail remarkably strong and pointed; ears long, or of a middling size; no whiskers.

* 1. *K. giganteus*, Geoff. *Didelphis major*, Lin. *Macropus major*, Shaw, &c. *Great kanguroo*. Brownish, with sharpish ears, and the fore feet furnished with five toes. 2. *K. philander*, Geoff. *Didelphis brunnii*, Lin. *Javan opossum*. Short naked tail, and long-toed hind feet.

* 1. *K. giganteus*. (Plate CCCLV. Fig. 23.) We have an account of the first discovery of this singular and elegant quadruped in Cook's Voyages. The general size of a full grown kanguroo is at least equal to that of an ordinary sheep; but some specimens have been met with, which were nearly nine feet in length from the tip of the nose to the end of the tail, and which weighed upwards of 150lb. The greatest circumference is round the bottom of the belly and hips, as it is very slender about the head and neck, and increases gradually downwards. The fore legs of the largest individuals are about nineteen inches in length, and the hinder three feet seven inches. From this extraordinary disproportion, it has been generally presumed that the former are incompetent to the purposes of walking or running, and only serviceable in digging the earth, and in conveying food to the mouth; but Labillardière mentions that one of his people shot a young kanguroo on the shore, which used all its four feet in attempting to make its escape; and those who have contemplated the animal when at large, must have remarked, that it every now and then places its fore feet on the ground. The hind legs, which are bare and callous beneath, are very strong; and when sitting, the animal rests on the whole of their length, its rump being elevated several inches from the ground. The head somewhat resembles that of a deer; and the expression of the countenance is mild and placid. The eyes are large, the mouth is rather small, and the neck is slender and finely proportioned. The prevailing colour is an elegant pale brown, lighter, or more inclining to whiteness, on the abdomen. The pouch is situated in the same manner as in the opossum, and is extremely

large and deep. Within it are two teats, although, in so far as has been hitherto observed, the female brings but one young at a time, and that so very diminutive at its exclusion from the uterus, as scarcely to exceed an inch in length, and to weigh but 21 grains. At this early period of its growth the mouth is merely a round hole, just large enough to receive the point of the nipple; but it gradually extends, till it is capable of receiving the whole nipple, which then lies in a groove formed in the middle of the tongue, and well adapted to that purpose. It seems probable, that, in the first state, it is attached to the teat by a viscid substance, which is always found in the uterus. At this time, feeble as it may appear in other respects, the fore paws are comparatively large and strong, to facilitate its motions in the pouch, whereas the hind legs, which are afterwards to become long and stout, are both shorter and smaller than the others. The young one continues to reside in the pouch till it has attained its full conformation; and even after it has quitted the maternal retreat, it often runs into it for shelter on any appearance of danger.

From the peculiar structure of the kanguroo, there can be little doubt that its principal progressive motion is performed by leaps. It has, in fact, been seen to spring over twenty feet at a bound, and this so often repeated in succession, as to rival the fleetness of the grey-hound; besides which, it has been known to clear an obstacle of nine feet perpendicular height. It has also great strength in its tail, which it sometimes employs as a weapon of defence, and with which it can strike so forcibly as even to break a man's leg. When seized by the hounds, it turns round in a moment, and catching hold with the nails of its fore paws, strikes with those of its hind feet, and wounds its persecutors severely. The native dogs of the country, which are fiercer than our greyhounds, hunt and kill the kanguroo with more certainty.

This quadruped generally feeds standing on its four feet, and drinks by lapping. When in a state of captivity it has sometimes a trick of springing forward, and kicking with its hind feet in a very forcible manner. Like the *Mus maritimus*, it has the property of separating to a considerable distance, and at pleasure, the two long front teeth in the upper jaw. It lives entirely on vegetable substances, and chiefly on grass. In their natural state, they are said to feed in herds of thirty or forty; and one is generally observed to be stationed on the watch at a distance from the rest. When fed on hard food it has been observed to ruminate; but this is by no means its constant practice, although, from the peculiar structure of its stomach, regurgitation of the contents of that viscus into the mouth is very easily performed.

The kanguroo may now be considered as in a great measure naturalized in England, having propagated in the royal domain of Richmond, where they have been kept for a series of years. Their flesh has been compared to that of coarse mutton.

SECTION II.

B. Two cylindrical and very strong cutting teeth in each jaw; a pouch under the belly of the female; fore and hind feet of nearly equal length; five strong toes on each foot, furnished with very stout claws, with exception of the hind thumb, which is separated and clawless; clavicles and marsupial bones; ears of moderate size; tail very short; body squat. Resident in New Holland.

1. Genus PHASCOLOMYS, Geoff. Characters corresponding with those of the section.

1. *P. Australasiensis*, *Australasian phascolomys.* Hair brown, bushy, long; tail remarkably short.

SECTION III.

C. Two cutting teeth, very much compressed, and as broad as high; no abdominal pouch; extremities of nearly the same length; five toes on each foot, of which four of those on the fore feet much elongated; thumb on the hind feet separated, and furnished with a flat nail; ears large and naked; clavicles in the skeleton; tail very long and bushy; two inguinal mammæ. Resident in the East Indies.

1. Genus CHEIROMYS, Cuv. SCIURUS, Lin.

1. *A. Madagascariensis*. *Madagascar squirrel.* Black, with the nose, ears, and under parts yellow-white.

SECTION IV.

D. Two very long cutting teeth in each jaw; no abdominal pouch, or separate thumb on the hind feet. They constitute the *Rodentia*, or *Gnawers*, properly so called, and are distributed into the ensuing families.

First Family. SCIURII, or the *squirrel* tribe. Cutting teeth simple, compressed, sharp-edged; tail long, furnished with hair parted by a furrow; extremities nearly equal in length; five toes on the hind feet, four on the fore feet; entire clavicles; ears straight, and of moderate length; eyes large.

The animals belonging to this elegant family are remarkable for the liveliness of their dispositions, the quickness of their motions, and the general beauty and neatness of their appearance. They climb trees, and spring from branch to branch with astonishing agility. Some of them are furnished with hairy membranes, in the form of a lateral and expansile skin, which enables them to leap occasionally from one tree to another. But though, from this circumstance, they are called *flying squirrels*, they are incapable of continuing their volant motion in the manner of bats. The tails of all the tree squirrels are very long, bushy, and light, having the long hairs so extended towards one another, as to render this appendage wider than deep. In the extensive leaps which the animals take from tree to tree, their tail seems to serve the same purpose which the feather does to an arrow; for it balances the body, and renders their motion through the air much more steady than it would otherwise be.

The greater number of the species live almost entirely in woods, and make their nests in the hollows of trees; but others burrow in the earth, and are therefore called *ground squirrels*. They live entirely on vegetable food, particularly nuts and other fruits. When on the ground they advance by leaps, and in eating they sit erect, and hold their food in their fore paws. Many of them may with care be rendered docile; but when irritated they attempt to bite. The skins of all the species are considerably valued as fur, and their flesh is a very palatable food.

1. Genus PTEROMYS, Cuv. SCIURUS, Lin. Skin of the sides extended into a membrane between the fore and hind feet. Inhabits both continents.

1. *P. petaurista*, *Sciurus petaurista*, Lin. *Taguan*, or *sailing squirrel*. Deep chesnut, and sometimes black above, whitish beneath. * 2. *P. volans*, *Sciurus volans*. Lin. *Polatouche*, *common European*, or *Lapland flying squirrel*. Pale grey above, white beneath. 3. *P. Canadensis*, Geoff. *Sciurus volans*, var. Lin. *Japan*, or *Canadian flying squirrel*. Whitish grey above, fine white beneath. 4. *P. volucella*, *Sciurus volucella*, Lin. *Virginian flying squirrel*. Brown above, yellow-white beneath. 5. *P. Sabrina*, *Sciurus sabrinus*, Lin. *Severn flying squirrel*. Rusty brown above, yellowish-white beneath, with flattish and villous tail.

**P. volans*. (Plate CCCLV. Fig. 24.) The length from nose to tail is about six inches and a quarter; the tail is shorter than the body, thickly furred, of a slightly flattened form, and rounded at the extremities. That it may the better accomplish its flying movement, the thumb of the fore feet is stretched out to a considerable length within the membrane, so as to appear in the skeleton like a long bony process.

This species inhabits the birch and pine woods of Finmark, Lapland, Lithuania, &c. and occurs in the woods of the Uralian mountains, and in the country which intervenes between that chain and the river Kolyma. It is the only flying squirrel that has been hitherto observed in Europe. It resides in the upper hollows of trees, where it makes its nest of the softest mosses. Except in the breeding season it leads a solitary life; and it never appears in the day-time. It subsists principally on the leaf buds and catkins of the birch, and on the buds and tender shoots of pines, which impart to its juices a strong resinous odour, and to its excrement the property of burning strongly, and with a pitchy scent. It seldom comes forth in bad weather; but certainly does not hybernate, as it is frequently taken during winter in the traps that are laid for the grey squirrel. From the similarity of its colour to that of the birch bark, it is often preserved from the attacks of predacious birds. In springing from tree to tree, it neither takes a horizontal nor a perpendicular, but an oblique direction, and glides from the top of one to the middle of another. The female brings two or three, and sometimes four, at a brood. When she goes abroad in quest of provender, she carefully wraps up her young in the moss of the nest. When by them, she bestows on them the most marked attentions, brooding over them, and, with her expanded membrane, sheltering them from the cold. They are produced without hair, remain blind for fourteen days, grow very slowly, and can scarcely be preserved alive if taken from the nest. The full grown individuals are tamed with difficulty, and are very apt to pine and die in confinement. Their furs are of little value, though often put into the bundles of those of the grey squirrels, with a view to defraud the purchaser.

2. Genus Sciurus, Lin. &c. Lateral flying membrane wanting. Resident in both continents.

* 1. *S. Vulgaris*, *Common squirrel*. Reddish brown above, white beneath; ears pencilled, or bearded at the tip. 2. *S. cinereus*, *Grey squirrel*. Cinereous above, white beneath; ears beardless. 3. *S. Caroliniensis*, *Carolina squirrel*. Body mixed with grey, white, and rust colour above, white beneath; ears naked; tail brown, mixed with black, and edged with white. 4. *S. capistratus*, Bosc. *Black-cap squirrel*. Colour varying from white-grey to perfect black; extremity of the nose and tips of the ears white; crown of the head black. 5. *S. maximus*, *Great*, or *Malabar Squirrel*. Brown above, with three longitudinal yellow stripes, pale beneath; tail marked with black stripes. 6. *S. dschinschicus*, *Carnatic squirrel*. Body of a brick-dust colour; lateral stripes and orbits white; tail black. 7. *S. æstuans*, *Brazil squirrel*. Grey above, yellow beneath; a white stripe along the belly; tail round, and ringed with black and yellow. 8. *S. pusillus*, Geoff. *Dwarf squirrel*. Light brown, shaded with olivaceous; whiskers black. 9. *S. Flavus*, *Fair squirrel*. Yellow, with rounded ears. 10. *S. Hudsonius*, *Hudson's Bay squirrel*. Ears naked; back dark grey; belly ash-coloured; tail dark grey, ringed, and tipt with black. 11. *S. Madagascarensis*, *Madagascar squirrel*. Black, with the nose, ears, and under parts yellowish-white, and very long; taper tail. 12. *S. niger*, *Black squirrel*. Black, with beardless ears. 13. *S. variegatus*, *Coquallin squirrel*. Somewhat rusty above, orange-tawny beneath, with the upper parts varied crosswise with black, brown, and whitish. 14. *S. rufiventer*, Geoff. *Tawny bellied squirrel*. Black rufous brown; belly dingy rufous; tail brown at the base, and somewhat tawny at the tip. 15. *S. erithopus*, *Digging squirrel*. Back grey-brown; belly grey; tail brown, and sprinkled with yellow hairs. 16. *S. Getulus*, *Barbary squirrel*. Brown, with four longitudinal white stripes. 17. *S. palmarum*, *Palm squirrel*. Brown above, pale below; the upper parts marked with three longitudinal yellowish stripes, and the tail with blackish stripes. 18. *S. striatus* and *Mexicanus*, Lin. *Striped*, or *Mexican squirrel*. Yellowish or ash brown, with five or seven longitudinal white or black stripes.

* *S. vulgaris*. The common squirrel usually measures about eight inches from nose to tail, and the tail about seven. In winter it is tinged with a deeper cast of grey, and in the northern latitudes it becomes completely grey. The ears are ornamented with long tufts of hair; the eyes are large, black, and lively; the fore legs are curiously furnished with strong stiff hairs, which project on each side like whiskers; and the claws are so strong and sharp that the animal can readily ascend the smoothest trees. Its greatest ornament is the tail, which serves as a protection from the cold, being large enough to cover the whole body, as the long hairs are disposed horizontally on each side.

This species is a native of almost all parts of Europe; as well as of the northern and temperate portions of Asia. In Siberia it is extremely abundant; whilst in the Crimea, where the forests yield an exuberance of nuts, not a squirrel is to be found. Early in spring, the males are particularly nimble and frolicsome, and may be observed to exhibit wonderful proofs of agility, while the females, like true coquettes, feign to avoid them by a variety of entertaining sallies. In warm summer evenings, they may also be seen playing their gambols among the trees; but they seem to dread the heat of the sun; for, during the day they commonly remain in their retreats, reserving their principal excursions for the night. This retreat, or nest, is generally formed among the large branches of a great tree, where they begin to fork off into small ones. Having selected the part where the timber is beginning to decay, and where a hollow may be more easily effected, the squirrel commences her operations by making a kind of level between these forks, and then fetching twigs, moss, and dry leaves, binds them so closely that they can resist the most violent storm. This part of the structure is covered on all sides, and has but a single opening at top, just large enough to admit the animal; and this opening is itself defended from the weather by a kind of canopy, formed like a cone, so as to throw off the rain, however heavy it may fall. The inside is soft, roomy, commodious, and warm. The store of nuts, acorns, &c. which these provident creatures lay up for their subsistence during winter, is seldom found in the nest itself, but in the hollows of the tree, carefully heaped, and where it is never touched but in cases of emergency, when no food is to be had abroad. Thus the same tree serves for a retreat and a magazine; and, without leaving it during the winter, its inhabitant possesses all those enjoyments which its nature is capable of receiving. If the winter should prove more severe and tedious than usual, the stock of provisions is sometimes consumed before the ground is quite uncovered. In this case, which seldom occurs, the animal descends from the tree, and scratches under the snow, where it finds sufficient food to preserve its existence till the trees again put forth their buds.

This little quadruped is extremely watchful; and it is alleged, that if the tree in which it resides is but touched at the bottom, it instantly takes the alarm, quits its retreat, and glides from tree to tree till it is beyond the reach of danger. For some hours it remains at a distance from home until the alarm has subsided, and then it returns by paths, which, to nearly all quadrupeds but itself, are utterly impassable. Owing to its wonderful activity, it is very difficult to take a full grown squirrel alive; but school-boys sometimes contrive to lay hold of it, by assembling in the woods, and pursuing the animal with loud noises, when it seems to lose its presence of mind, and fall to the ground. The squirrel expresses the sensation of pain by a sharp piercing cry, and that of pleasure by a sound not unlike the purring of a cat. Besides, when teased or irritated it occasionally utters a loud growl of discontent. It has been remarked, that its gullet is very narrow, to prevent the food from being disgorged, in descending trees, or in leaping downwards. The squirrel is not met with in open fields, and seldom near houses, but affects tall and aged forests. It has an aversion to water, and satisfies its thirst with the dew or rain collected on the leaves, and in the hollows of trees. In summer, it feeds on almonds, walnuts, hazel nuts, filberts, beech-mast, acorns, and the buds and young shoots of trees. In a state of captivity, it will also eat a great variety of fruits, and other vegetable substances, and is delighted with sugar and sweetmeats. The young are generally three or four in number, and are produced about the middle of summer, and sometimes earlier. They are capable of being tamed, but not without trouble and attention; and in a domestic state they exhibit great individuality of talent and disposition. It is a cleanly animal, destitute of offensive odours, and, as an article of food, not unpalatable. In some parts of Scotland, into which squirrels have been introduced, they have proved very hurtful to young plantations.

Second Family. Glirini.

Cutting teeth in the upper jaw, simple and wedge-shaped; those in the under jaw slightly sharpened or obtuse; grinders grooved; no cheek pouches; the posterior extremities always much longer than the anterior; tail long and hairy; eyes large; ears pretty long; body lengthened and slender.

1. Genus Dipus, Lin. &c. Heels very high; nose short and broad; hinder extremities very long; toes of the hind feet varying in number from three to five, placed unequally; claws triangular; only four toes on the fore feet, furnished with crooked claws, with the rudiments of a clawless thumb; tail covered with smooth hair at its base, and more bushy at the extremity; glands of the male furnished with two horny hooks, and sometimes with spoon-shaped papillæ: ears pointed. Resident in the old continent.

* 1. *D. sagitta*, Lin. *Common*, *Arabian*, or *Egyptian Jerboa.* Pale brown above, white beneath; hind feet very long, with three toes; tail very long, with a black and white feather-like tip. 2. *D. jaculus*, Lin. *Siberian Jerboa*, or *alagtaga.* Pale brown above, white beneath; hind feet three-toed, with two spurious toes above. 3. *D. cafer*, Lin. *Cape Jerboa.* Ferruginous above, pale ash-coloured beneath; fore feet with five toes; hind feet with four; tail very hairy, and tipped with black.

* *D. sagitta.* (Plate CCCLVI. Fig. 25.) The ordinary length from nose to tail is about seven inches and a quarter, and of the tail about ten inches. The dimensions, however, are variously stated by different writers; and a considerable degree of confusion and discrepancy seems to have obtained in adjusting the several species and varieties. That now before us is about the size of a rat, and is frequently marked by an obscure dusky band on the upper part of the rump; the fore legs are an inch, and the hind six inches long. On each side of the nose are several very long hairs or whiskers. The females have eight teats, six of which are placed further out on the body than in other quadrupeds, and the other two are rather under the thighs than the belly. The males are a little smaller, and for the most part lighter coloured than the females.

The common Jerboa inhabits not only Arabia, Syria, Egypt, Barbary, and other districts in Africa, but also the sandy deserts between the Tanais and the Volga. In its attitudes and hopping motions it so much resembles a bird, that some have regarded it as a link in the chain that connects quadrupeds with the feathered race. It may generally be seen standing like the kanguroo on its hind feet, or leaping to a considerable distance. Sometimes it sets its fore feet to the ground for a moment or two, and then recovers its former attitude. It principally uses the fore legs in feeding, putting to its mouth the ears of corn, and various other vegetable substances on which it feeds. It resides in subterranean holes, which it either prepares itself, or finds ready excavated in the dry, stony, and sandy deserts which it frequents. It is with difficulty preserved in a state of captivity, or transported into the climates of Europe. The cages or tubs in which it is conveyed should be well secured, and lined with tin; for as it is naturally disposed to gnaw every thing that comes in its way, several of them, in the course of a long voyage, might not only do considerable mischief, but even endanger the safety of the vessel.

2. Genus Gerbillus, Desmar. Mus, Lin. Dipus, Oliv. and Geoff. Heels slightly elevated; head pretty much lengthened; hinder extremities very long, terminated by five toes nearly equal; four toes and a thumb without nails, on the fore feet; nails sharp and not raised; tail very long, and thinly covered with some long hairs at the tip; ears rounded. Resident in the two continents.

1. *G. Ægyptius*, Desmar. *Mus longipes*, Lin. *Jird*, or *small Jerboa.* Yellow above, white beneath. 2. *G. Canadensis*, Desmar. *Canadian Jerboa.* Head small; ears very short; tail longer than the body. 3. *G. pyramidum*, Desmar. *Jerboa of the Pyramids.*

3. Genus Myoxus, Lin. &c. Heels slightly raised; head lengthened; posterior very little longer than anterior extremities, and furnished with five toes, armed with crooked claws; four unguiculated toes on the fore feet, and the thumb represented by a clawless prominence; tail very long, and covered throughout with pretty long hairs; ears rounded. Resident in both continents.

* 1. *M. glis*, Lin. &c. *Fat dormouse.* Grey above, white beneath. 2. *M nitela*, Lin. &c. *Garden*, or *greater dormouse* or *sleeper.* Body tawny above, whitish-ash beneath, with a black circle round the eyes, and a black spot behind the ears. * 3. *M. muscardinus*, Lin. &c. *Common dormouse*, or *sleeper.* Body tawny, throat whitish. 4. *M. dryas*, Lin. &c. *Wood dormouse.* Tawny-grey above, dirty-white beneath; a straight black line from ear to ear across the eyes. 5. *M. chrysiurus* Geoff. *Golden-tailed dormouse.* Purplish brown, with the hind part of the tail and longitudinal stripe on the head gold-yellow. 6. *M. tamariscinus*, *Dipus tamariscinus*, Lin. *Tamarisk jerboa.* Yellow-brown above, white below; tail tapering and obscurely ringed with brown. 7. *M. degus*, *Sciurus degus*, Lin. *Chilian squirrel.* Yellowish brown, with a black stripe on each shoulder.

* *M. Glis.* Length, from nose to tail, nearly six inches, and that of the tail four inches and a half; the body is much thicker, in proportion, than that of the squirrel; the tail is very furry, and slightly spreading; the eyes are large and black, and the ears thin, rounded, and very slightly haired.

This species is not, it should seem, to be found in very hot or very cold climates, but rather in the temperate and wooded regions of the globe, as in some parts of Russia, Germany, Switzerland, France, Spain, Italy, and Greece; dwelling in upland forests, and becoming torpid whenever the external atmosphere is cooled below the natural warmth of its blood, which does not exceed $54\frac{1}{2}^{\circ}$ of Fahrenheit's scale. Like the squirrel, it lives in trees, and is capable of leaping from one to another, and from spray to spray, but with less nimbleness and alacrity than the squirrel. It prepares a bed of moss in hollow trunks of trees, or in the clefts of elevated rocks, and in dry situations; for it appears to be averse to moisture, drinks little, and rarely descends to the ground. Its food is very analogous to that of the squirrel. Its breeding season commences in the end of spring, and a litter of four or five is produced in summer. The young grow rapidly, and it is alleged that they seldom live more than six years.

The fat dormouse is scarcely susceptible of domestication, and defends its life with great courage to the last extremity; biting fiercely with its very long and strong front teeth, and dreading neither the weasel nor birds of prey. From the fox it escapes by climbing up into trees: but it less easily eludes the wild-cat and the martin. It is the *glis* of the ancient Romans, who reckoned it among their articles of luxury, and fattened it in appropriate receptacles, called *gliraria.* That, contrary to the nature of other hybernating animals, it fattens during its torpor, is a prejudice as old as the days of Martial; but the truth is, that it is at all times fat, and as much so in spring as in autumn, because it awakens as often as the temperature of the air surpasses that of its blood, and has recourse to its stock of provisions. In Italy, where its flesh is still prepared for the table, the people dig ditches in the woods, line them with moss, cover them with straw, and deposit in them a quantity of nuts and beech-mast; selecting for this little establishment the sheltered shade of a rock, exposed to the south, and free from moisture. Thither the dormice resort about the end of autumn, when they are caught in their lethargy.

* *M. muscardinus.* In respect of size, this species may be compared to the common mouse; but it has a more plump appearance, and a more obtuse nose. The eyes are large, black, and prominent; the ears broad, rounded, thin, and semitransparent; the fur is remarkably soft, and the whole animal has no inelegant appearance. It inhabits most of the countries of Europe; but, as it seldom wanders far from its retreat, it is supposed to be of rather rare occurrence.

Dormice affect woods, or very thick hedges, and form their nest in the hollow of some low tree, or near the bottom of some close shrub, composing it of grass, moss, and dead leaves. It is about six inches in diameter, and open only above. The number of young is usually three or four. Like the squirrel, these little quadrupeds form magazines of nuts, beech-mast, &c. and take their food in an upright posture; but they are much less lively and alert than the squirrel. Retiring into their holes on the approach of winter, and rolling themselves up, they lie dormant during the greater part of the gloomy season, experiencing sometimes a short revival in a sunny day, when they take a little food, and then relapse into their former state. From their benumbed condition nothing can effectually rouse them but the application of a gentle and graduated heat; for, when suddenly placed near a fire, they uniformly die. Even in their torpid state they are sensible to acute pain; for, when burned or wounded, they contract their bodies, and utter low and repeated cries. Hence we may infer that the action of the heart and lungs still subsists, though in a very feeble degree. The circulation of the blood is probably limited to the large vessels; for the respiration is slow and languid, the secretions are inconsiderable, and there is no extrusion of fæces.

Third Family Cricetini. The four extremities of nearly equal length; five unguiculated toes on the hind feet; only four, and a clawless tubercle, in place of a thumb, on the fore ones; entire clavicles; sometimes cheek-pouches; tail hairy, and often very short; eyes large; ears short; body squat.

1. Genus Arctomys, Lin. Geoff. &c. Upper and lower cutting teeth bevelled; grinders with sharp prominences; ten in the upper, and only eight in the lower jaw; no cheek-pouches; head flat; legs short; tail short, and covered with pretty long hair; external ears scarcely obvious. Resident in both continents.

* 1. *A. marmotta*, *Alpine marmot.* Ears short and round; body brown above, rufous beneath. 2. *A. citillus*, *Variegated*, or *earless marmot; Susslik* of the Russians. External ears scarcely visible; body yellowish-brown, with many small white spots; tail very short. * 3. *A. monax*, *Maryland marmot*, *Monax*, or *American marmot.* Ears short and round; nose bluish; body grey; tail long and hairy. 4. *A. bobac*, *Bobac*, or *Bobac marmot.* Ears small and oval; body grey above: rufous or yellowish beneath. 5. *A. maulina*, *Mauline marmot.* Ears sharp-pointed; tail of moderate length.

* *A. marmotta*, (Plate CCCLVI. Fig. 26.) This animal, when full grown, is about the size of a rabbit, and has been compared to a diminutive bear, or badger; but the disposition of its teeth, and its internal conformation, demonstrate its affinity to the murine tribe.

These marmots frequent the higher regions of the Alps and Pyrenees, and are also found in some districts of Asia, preferring small narrow valleys, particularly the western or southern aspect, and shunning moist places. About the end of September, or early in October, they retire into their holes, and do not come abroad again till the beginning of April. In the formation of their dwellings, they scoop out the earth with great dexterity and expedition. By throwing away a small part, and beating the remainder close, they render the passage very compact and solid. The opening, being scarcely more than six or seven inches in diameter, is just large enough to admit the animal. The interior excavation is from eight to twenty feet in length, and consists of a passage, which, at about five or six feet from the entrance, divides into two branches; the one leading to a small cavity, and the other to the apartment in which they repose. The passage and the two branches are always conducted in a straight line, unless the intervention of a rock, or any other impediment, obliges them to take another direction. Their dwelling-place, or chamber, is round or oval, arched at top, and, in its form, resembles an oven. It is from three to seven feet in diameter, being larger or smaller according to the number of the family, and is well lined with moss or hay, of which they lay up great store during the summer. For the winter they require no provisions; but when they feel the first approaches of the sleeping season, they shut up both the passages to their apartments, so as to exclude the air, by means of a cement, composed of earth, stones, and hay, which renders the stoppage very close and solid. When they enter on their brumal slumber they are very fat, and they continue so for nearly three months; but afterwards they gradually decline, and by the end of winter are considerably emaciated. In their torpid state they lie on the hay, close to one another, and rolled up like hedgehogs, without exhibiting any visible symptom of life. From five to sixteen are usually found together, and sometimes, though rarely, two families occupy the same dwelling. A few instances have occurred of one having been found by itself. Like dormant and other hybernating animals, they are revived by a gentle and gradual heat. On quitting their winter habitations, they remove the cement at the entrance, not by pushing it outwards, but by drawing it inwards. At first, they descend to the lower regions of the mountains, where vegetation is more advanced; and, in summer, again mount to the rocky heights, and into solitary caverns. Their food consists of various herbs and roots, particularly of alpine plantain, mountain spignel, alpine lady's mantle, mountain sorrel, alpine toad-flax, trefoil, and star-wort. They breed early in the summer, and the litter commonly consists of three or four, the growth of which is observed to be very rapid. At break of day, the old marmots come out of their holes and feed, and afterwards bring out their young. The latter scamper on all sides, chace one another, sit on their hind feet, and remain in that posture, facing the sun, with an air expressive of satisfaction. They are all particularly fond of warmth; and, when they reckon themselves secure, will bask in the sun for several hours. Before they collect grass, either for food or for their winter abodes, they form themselves into a circle, sitting on their hind legs, and looking about on all sides; but, on the least alarm, they immediately hasten to their hiding-places. They have great quickness of sight, and discover an enemy at a considerable distance. They never wantonly inflict the slightest injury on any other animal; and, when apprehensive of invasion, they forsake their dwellings in entire families, and wander from mountain to mountain, although they are thus necessitated to construct new retreats. When flight, however, is impracticable, they defend themselves with spirit against even men and dogs; and assail, with their teeth and claws, all who approach them. In winter they are taken in great numbers, both on account of their flesh, which is tender and palatable, and for their skins, which are used as furs. A young Alpine marmot is easily domesticated, and may, without much trouble, be taught to walk on its hind feet, to sit upright, &c. To please its master, it will even dance with a stick between its paws, and perform a great variety of feats In its tame state, it will eat of almost every thing but flesh. When drinking, it raises up its head at every sip, like a fowl, looking on each side with a timid watchfulness. In general, however, it drinks but little. It is very partial to milk and butter, and manifests a particular aversion to dogs. In a domestic state, being kept sufficiently warm, it dispenses with hybernation.

2. Genus Cricetus, Cuv. and Geoff. Mus, Lin. Glis, Erxleb. Upper cutting teeth bevelled; lower conical and pointed; six slightly grooved grinders in each jaw; cheeks furnished with pouches; body more elevated on the legs than in the preceding; tail very short, and covered with hairs of a very moderate length; external ears of a middling size. Resident in both continents.

* 1. *C. vulgaris*, *Mus cricetus*, Lin. *Hamster*, *Hamster rat*, or *German marmot*. Reddish-brown above, with three white spots on each side, and deep black abdomen. 2. *C. furunculus*. *Mus furunculus*, Lin. *Mus barabensis*, Pallas. *Baraba rat*, or *orozo*. Yellowish-grey above, whitish beneath, with a black dorsal streak. 3. *C. phæus*, *Mus phæus*, Lin. *Astrachan mouse*. Ash-brown above, white beneath. 4. *C arenarius*, *Mus arenarius*, Lin. *Sand rat*. Ash-coloured, with the feet, sides of the body, belly, and tail, white. 5. *C. songarus*, *Mus songarus*, Lin. *Songar rat*. Cinereous above; sides patched with white; back marked with a black line; under parts white. 6. *C. tscherkessicus*, *Glis tscherkessicus*, Erxleb. *Mus tscherkessicus*, Pallas. *Circassian hamster*. Chesnut; fore-feet much shorter than the hind. 7. *C. migratorius*, *Mus migratorius*, Pallas. *Migratory rat*, or *hagri* Cinereous-grey above; the nose, extremities of the feet, and the under parts, white. 8. *C. laniger*, *Mus laniger*, Lin. *Chincilla*, *or Woolly mouse*. Body cinereous and woolly; fore-feet with four toes; hind with five. 9. *C. acredula*. *Mus acredula*, Lin. *Yaik rat*, or *Siberian hamster*. Ears plaited: yellow-grey above, whitish beneath. 10. *C. bursarius*, *Mus bursarius*, Lin. *Canada rat*. Ash-coloured; tail short, and nearly naked; claws of the fore-feet very large, and formed for burrowing.

* *C vulgaris*. The hamster is about the size of the brown or Norway rat, but its body is much thicker, and the tail only three inches long. The males, which weigh from twelve to fifteen ounces, are always considerably larger than the females, which generally weigh only from four to six ounces. On each side of the lower part of the back is an almost bare spot, covered only with very short down, and very visible when the latter is blown aside. The colour of this species is liable

to vary, and about Casan the animal is found quite black. The cheek-pouches, when empty, are so much contracted as not to appear externally; but, when filled, they resemble swollen bladders, having a smooth veiny surface, concealed, however, under the fur of the cheeks, which then appear very much inflated. These receptacles are large enough to hold a quarter of a pint, English measure, or three ounces of grain at a time; and they are furnished, internally, with various glands which secrete a lubricating humour, and thus preserve them flexible and uninjured by the sharp angles of the grain. The animal empties the contents of these pouches into its storehouse, by pressing its forefeet against its cheeks. When the latter are replenished, it may be easily caught by the hand, without any risk of biting, as it has not then the free use of its jaws. On dissecting a specimen, Dr. Russell found the pouch, on each side of the mouth, stuffed with young French beans, arranged lengthwise, and so exactly pressed on each other, that it appeared strange by what mechanism this had been effected; for the membrane which forms the pouch, though muscular, is extremely thin, and the most expert fingers could not have packed the beans in more regular order. When they were laid loosely on the table, they formed a heap thrice the bulk of the animal's body. In point of internal conformation, the hamster is nearly allied to the water-rat. It is very common in all the regions of Southern Russia, especially in the most fertile and best cultivated districts; nor is it rare even in the whole of the Tartarian desert, and in the more southern plains of Siberia, as far as the Jenesei, but it is never found beyond it. In the deserts it leads a roaming life, and is partial to the grounds which produce the greatest quantity of liquorice, the seeds of which plant constitute a principal article of its food. It is frequent in Poland, Hungary, Bohemia, and many parts of Germany; and its multiplication is sometimes so prodigious as to occasion a scarcity of grain. M. Sulzer informs us, that, in one year, about 11,000 skins; in a second, 54,000; and in a third, no fewer than 80,139 were brought to the town-house of Gotha, as vouchers of claims to the premiums allowed for the destruction of these petty depredators.

The hamsters construct their habitations differently, according to their age, sex, or the quality of the ground. The male works an oblique subterraneous passage, and disposes of the earth at the mouth, where it lies in a heap. At a distance from this oblique passage, there is a hole which descends perpendicularly into the chambers of the lodging. The males and females have separate dwellings; that of the female being the deepest, and having, besides the oblique openings, two, three, or more perpendicular holes, that their young may pass in and out at pleasure. On each side of these perpendicular holes, at a proper distance, the hamsters of both sexes dig from one to four cavities, in the form of vaults; and as these places are intended to serve for magazines of grain, they always proportion their dimensions to the quantity of their provisions.

The females produce twice or thrice a-year, from six to eight at a litter; and so rapid is the growth of the young, that, at the age of fifteen days, they begin to dig the earth, and are soon after banished by the mother, to seek a living where they can. About the end of August, these animals begin to lay up their stock of provisions, not for their winter support, but for their nourishment previously to the commencement, and after the conclusion of their hybernation. These stores consist of dry clean grain, corn in the ear, peas and beans, &c.; the quantity housed depending on the size and sex of the inhabitants, and varying from about twelve to a hundred pounds weight. When the whole is deposited, it is carefully covered. On the approach of the cold season, each hamster retires into its cell, closes all the avenues with earth, and remains in perfect tranquillity till the frost becomes severe, when it gradually sinks into a state of torpor. On dissecting the animal in this situation, the heart, indeed, is observed to contract and dilate, but with such a languid motion, that the pulsations do not exceed fifteen in a minute, in place of a hundred and fifty; the blood remains fluid, but the fat is congealed, and the intestines are not only as cold as the external parts of the body, but betray no symptoms of irritability, on the application of spirit of wine, or oil of vitriol. Even the electrical shock cannot rouse the hamster from its deep lethargy. At the appointed time in spring, the creature gradually begins to shew some signs of returning animation. He first loses the stiffness of his limbs, and then makes profound respirations, but at long intervals: he begins to move his legs, opens his mouth, and utters disagreeable and rattling sounds. After continuing these operations for some time, he opens his eyes, and endeavours to raise himself on his legs; but all his movements are still reeling and unsteady. At length, however, he recovers himself sufficiently to stand with firmness. In this attitude he remains fixed, as if he meant to reconnoitre and repose himself after his fatigues, till gradually he begins to walk, to eat, and to act in his usual manner. This process of resuscitation occupies from one to two hours, according to the temperature to which the animal is exposed.

The active portion of a hamster's life is principally shared between eating and fighting; for it attacks, with heedless boldness, every animal that comes in its way. Ignorant of the art of saving itself by flight, above ground, rather than yield it will allow itself to be beaten to pieces with a stick. If it lays hold of a man's hand, it will sooner perish than let it go. The size of the horse terrifies it as little as the address of the dog. When it perceives the latter at a distance, bent on pursuit, it begins by emptying its cheek-pouches, if they happen to be filled with grain, and then blows them up to such a degree, that the dimensions of the head and neck greatly exceed those of the rest of the body. Raising itself on its hind legs, it darts on its adversary, and, if it catches hold, adheres to it with invincible obstinacy. The dog, however, generally seizes on it behind, and strangles it. This determined fierceness prevents the hamster from being at peace with any animal whatever; for it even makes war against its own species, when the stronger always devours the weaker.

The peasants, during the winter season, dig into the holes of these quadrupeds, and take them out folded up and torpid. Besides being rewarded by their skins, which are reckoned valuable furs, they frequently get a considerable stock of grain from their burrows. The flesh, though eatable, is coarse and unsavoury. When dried, pounded, and mixed with oats, it is said to induce premature fatness in horses, but which suddenly disappears, the animal falling into a fatal decline.

3. Genus Arvicola, Cuv. Lemmus, Geoff. Glis, Erxleb. Mus, Lin. Upper cutting teeth bevelled;

lower conical and pointed; grinders furrowed on their crowns and sides, as if formed of vertical plates soldered together; tail covered with short close-set hair; external ears of moderate dimensions; eyes pretty small, and no cheek-pouches.

*1. *A. vulgaris*, *Mus arvalis*, Lin. *Meadow mouse*, or *short-tailed field mouse*. Ears above the fur, body brown, tail short. 2. *A. amphibia*, *Mus amphibius*, Lin. *Water rat.* Tail half the length of the body; ears scarcely projecting beyond the fur. *3. *A. lemmus*, *Mus lemmus*, Lin. *Lemming*, or *lemming rat.* Tail short; ears shorter than the fur; body variegated, with tawny and black above, and white beneath. 4. *A. torquata*, *Mus torquatus*, Lin. *Collared*, or *ringed mouse.* Tail short; ears shorter than the fur; body rusty and variegated; a whitish collar round the neck, and a dark line along the back. 5. *A. alliaria*, *Mus alliarius*, Lin. *Garlic mouse.* Tail short; ears somewhat large; body cinereous above, whitish beneath. 6. *A. rutila*, *Lemmus rutilus*, Geoff. *Mus rutilus*, Lin. *Red mouse.* Rufous above; fulvous ash-coloured beneath; ears longer than the fur. 7. *A. fulva*, *Lemmus fulvus*, Geoff. Body of a bright fawn-colour, verging on yellow; ears scarcely visible. 8. *A. nilotica*, *Lemmus niloticus*. Geoff. *Nilotic rat.* Brown, blended with some shades of fawn; tail black above, and lighter-coloured beneath. 9. *A. socialis*, *Mus socialis* and *gregarius*, Lin. *Social mouse*, or *social rat.* Tail half an inch long; ears round and very short, body pale-grey above, and white beneath. *10. *A. œconoma*, *Mus œconomus*, Lin. *Economic rat.* Tail short; ears shorter than the fur; body brown. 11. *A. lagura*, *Mus lagurus*, Lin. *Hare-tailed mouse*, or *hare-tailed rat.* Tail short; ears shorter than the fur; body cinereous, with a longitudinal black line extending from between the eyes, along the neck and back to the tail. 12. *A. gregalis*, *Mus gregalis*, Lin. *Gregarious*, or *Baïkal mouse* or *rat.* Tail short, ears longer than the fur, body greyish.

**A. vulgaris.* According to Pennant this species is about six inches long, from nose to tail; but Buffon, and most other naturalists, reduce this measurement nearly one half. It is difficult to reconcile such a marked difference; but there can be little doubt that the size is subject to considerable variety. The tail is only an inch and a half, the head is remarkably large, and the nose blunt; the cutting teeth are very yellow, the eyes prominent, and the legs short. It is often harassed by parasitical insects.

The meadow-mouse inhabits the whole of Europe, and is very common in our own island, where it frequents moist in preference to dry situations, and is seldom known to infest gardens. Dr. Barry informs us, that the tracks made by these little quadrupeds among the moss and short heath, in the Orkney Islands, are about three inches in breadth, and sometimes extend for several miles in length, that they are much worn by constant treading, and that they are warped into a thousand different directions. As soon as the corn begins to ripen, these mice collect together from all quarters, and frequently commit great havoc by cutting the stalks in order to come at the ears. When all the corn is carried off from the fields, they generally resort to the newly sown lands; and if their numbers happen to be great, their depredations will sometimes frustrate the hopes of the succeeding year. They brave the rigours of the climate in the dreary wastes of Northern Russia, where they subsist on wild berries, and take up their abodes about hay-ricks, on the steep banks of torrents and rivulets, and on spots covered with herbage. They also occur in equal plenty in many parts of North America. Like several of their congeners, they are a migratory, gregarious, and hording race. The holes, which serve them at once for dwellings and magazines, are neither very spacious nor profound; but they are almost always divided into two or three compartments, in which several individuals live together. The lodges of different families or petty colonies are not contiguous, but separated by an interval more or less considerable. They seldom dig deeper than half a foot, or a foot at most; but the females, before bringing forth their young, frequently prolong the excavation by forming a narrow passage, or gallery, that penetrates a foot deeper, and, after various windings, terminates in a recess about the size of the fist, and softly lined with herbage, for the accommodation of her brood. The number of the latter varies from five to twelve. In some years, the multiplication of this species is excessive, and threatens whole districts with famine; for though they are capable of subsisting on nuts, acorns, &c. they are chiefly partial to corn, which they devour with great greediness, and also store up in their cells. In default of other food, they attack one another. They are also devoured by all the birds of prey.

**A. lemmus.* The size and colour of this singular species vary, according to the country which it inhabits, those which are found in Norway being almost as large as the water-rat, while those of Lapland and Siberia are scarcely larger than a field-mouse. The Norwegian is distinguished by an elegant variegation of black and tawny on the upper parts, disposed in patches and clouded markings, the sides of the head and the under parts of the body being white, and the legs and tail greyish. In the Lapland variety, the colour is chiefly tawny-brown above, with some indistinct dusky shadings, and dull white beneath.

The lemmings feed entirely on vegetables, particularly on roots, on the catkins of the dwarf birch, and on rein-deer moss. In summer, they form shallow burrows under the surface of the ground, and in winter, long passages under the snow, in search of food. The females breed several times in the year, and produce five or six at a brood. When irritated, they utter a sort of faint bark or squeak, and defend themselves with fierceness and obstinacy. The most extraordinary circumstance in their natural history is, their occasional migration, in immense multitudes, from their native mountains in Norway and Lapland, during the night, or early in the morning, their parallel bands of many thousands generally directing their progress from north-east to south-west. As these countless legions generally appear only after an interval of several years, the rude natives believe that they have descended from the clouds. The obstinacy with which they adhere to their undeviating line of march, is truly astonishing; for it is asserted, that they will rather plunge headlong into a river, torrent, lake, deep pit, or even a fire, than make a circuit. As they never enter houses, if they stumble on one in the direct course of their journey, they are said to stop short, and patiently await death; but they will gnaw their passage through a hay-rick or stack of corn. In traversing a meadow, they eat the roots of the herbage; and if they encamp on it, they render it perfectly useless for the purpose of pasture, the whole field appearing as if turned up and parched. It is even alleged that they infect the grass with deleterious properties, and convert it into noxious food for cattle; the supposition, however, that they are themselves poisonous, is certainly erroneous, because they are frequently eaten with impunity by the Laplanders, who compare their flesh to that of the squirrel. In calm weather, they swim across waters with great facility! but if a storm arise, they are instantly submerged, and die in great numbers. Few of them survive the springing of the grass; ermines, foxes, and birds of prey, lie in wait for their destruction; and they sometimes maintain murderous conflicts with one another. Their formidable migrations are supposed to originate in an unusual multiplication of the tribe in its native mountains, together with a defect of food, and perhaps a sort of prescience of unfavourable seasons; at least, it has been observed, that their chief movements are performed in the autumn of such years as are followed by very severe winters. The females have sometimes been observed to bring forth their young during their march, and to carry them in their mouths and on their backs. Though their hair is very fine, their skin is not of sufficient consistency to be manufactured into fur.

**A. æconoma.* The length of the males is about four inches and a quarter, and of the tail nearly one inch; the females are somewhat longer. The tail is truncated at its extremity, and furnished, through its length, with a series of scaly rings, from which arise numerous long hairs, partly brown and partly white.

Such is the fruitfulness of this species, that it overspreads all the low and moist vallies of Siberia, from the Irtisch to the Eastern Ocean, as well as those of Kamtschatka, although various carnivorous birds and quadrupeds assail it with incessant warfare. The sexes couple early in the spring, and the female brings only two or three at once, but breeds several times in the course of the year, diffusing, when in season, a very strong musky odour from the glands, situated near the vulva. A highly fetid smell also proceeds from the insides of such of these animals as are killed. They make their burrows with wonderful skill, immediately beneath the surface, in soft turfy soils, forming a chamber with a flattish arched roof, of a small height, and about a foot in diameter, with which they sometimes connect as many as thirty small tubes or entrances; and, near the chamber, they frequently form other caverns, in which they deposit their winter stores, consisting chiefly of roots, and sometimes weighing from twenty to thirty pounds. Most of these roots would afford wholesome nourishment even to man; but others, as of *chærophyllum temulum*, *aconite*, and a species of *anemone*, are known to produce deleterious effects on the human system. These hoarding quadrupeds gather their provisions in summer, harvest them with great care, and have sometimes even the precaution to bring them out of their cells to give them a more complete drying in the sun. The principal labour devolves on the females; for the males, during summer, roam about in a solitary state, taking up their occasional abode in some old nest, and living, during that period, on berries. The migrations of the tribe are scarcely less surprising than those of the lemmings. Owing to the scarcity of wild berries in Iceland, the economic rats, according to the testimony of Olaffsen, are obliged to cross and re-cross lakes and streams in a manner sufficiently ludicrous. "The party, consisting of from six to ten, select a flat piece of dried cow-dung, on which they place the berries which they have collected in a heap on the middle; and then, by their united force, drawing it to the water's edge, launch it, and embark, placing themselves round the heap, with their heads joined over it, and their backs to the water, their tails pendant in the stream, and serving the purpose of rudders."

Fourth Family. INAURITI, *Earless.* Body much lengthened; head as wide as the body; upper and lower cutting teeth simple, remarkably long, very strong, bevelled at the edge, the upper shortest; three cylindrical and flat-crowned grinders on each side in each jaw; legs short, the fore ones far distant from the hind; all the feet furnished with five toes, and very strong claws; clavicles remarkably strong; no external ears; eyes very small, sometimes wholly concealed beneath the skin, and apparently useless; tail either wanting, or represented by a mere tubercle.

1. Genus TALPOIDES. La Cépède, MUS, Lin. SPALAX, Erxleb. and Cuv. Skin of the head perforated at the eyes; rudiments of a tail; body inflated about the middle. Resident in both continents.

1. *T. capensis*, *Mus Capensis*, and *maritimus*, Lin. *Cape*, or *coast rat.* Pale-yellowish brown above, whitish beneath. 2. *T. minor*, *Mus talpinus*, Pall. *Mole rat*, or *surkerkan.* Brown, short-tailed, fore feet formed for burrowing. 3. *T. aspalax*, *Mus aspalax*, Pall. *Zokor*, or *Daourian rat.* Ash-grey above, whitish ash beneath; caudal tubercle naked. 4. *T. Hudsonius*, *Mus Hudsonius*, Pall. *Hudson's Bay mouse.* Ash-coloured above, white beneath, with a yellowish brown dorsal stripe.

2. Genus ASPALAX, Desmar. SPALAX, Erxleb. and Cuv. MUS, Lin. and Pall. Traces of concealed eyes under the skin, and beneath a tendinous expansion which stretches from the orbits; no tail; auditory canal very large; belly long; body straight and cylindrical. Resident in the eastern regions of temperate Europe.

**A. typhlus*, *Mus typhlus*, Lin. *Zemni*, *blind rat*, or *blind mole rat.* Brown above, dusky beneath. That this animal is totally destitute of eyes is not strictly true; but these organs are very minute, and seated beneath the skin. Aristotle had very accurately observed, that, on removing the skin, one may observe a tendinous expansion stretching over the orbits. Immediately underneath is a glandulous body, oblong, somewhat flattened, pretty large, near the centre of which is a black point, which represents the ball of the eye, and which, though not half a line in diameter, appears to be completely organized; so that it is not improbable that these subcutaneous rudiments of eyes may convey some faint perceptions of light, and thus enable the animal to consult its safety by generally remaining beneath the surface of the soil.

Olivier observed the blind rat in Asia Minor, Syria, Mesopotamia, and Persia, as Pallas did in Southern Russia, between the Tanais and the Volga. It is gregarious, and lives under ground like the mole. Its numerous and winding passages are seldom deep, but it forms, a little further down, commodious recesses in which to repose, without molestation from the rain water. It affects the most fertile and level grounds; and, as it feeds entirely on roots, seriously injures every kind of crop that happens to be within its reach. Its movements are generally quick, irregular, and abrupt. In the morning it sometimes quits its hole to bask in the sun; and, if disturbed, instantly takes refuge beneath the surface, burrowing with great agility, and frequently in a perpendicular direction. It runs backwards with the greatest ease, carrying its head erect, stops at the least noise, listens attentively, and, when attacked, bites severely. When irritated, it utters a kind of snorting sound, and gnashes its large teeth in a menacing manner. The females produce from two to four young. Olivier and Latreille seem to have proved, that this species is the *Aspalax* of Aristotle and the ancient Greeks, a term which the Romans, probably through inadvertence, applied to the common mole.

Fifth Family. Murini. Upper cutting teeth simple and wedged, the lower conical and sharp-pointed; three flat crowned and slightly grooved grinders in each jaw; no cheek-pouches; tail long, conical, scaly, or covered with hair so short as to be scarcely perceptible; extremities of nearly equal length, the posterior with five unguiculated toes, the anterior with only four, and the rudiments of a clawless thumb; toes never palmated; clavicles, external ears, and eyes, of moderate dimensions.

1 Genus Mus, Lin &c. Characters coincident with those of the family.

* *M. Musculus*, Lin. *Mouse.* Brown above, ash coloured beneath. 2. *M. sylvaticus*, Lin. *Long-tailed field mouse, field* or *wood mouse*, or *field rat.* Yellowish brown above, white beneath; breast yellow. * 3. *M. messorius*, Lin *Harvest mouse*, or *less long-tailed field mouse.* Upper part of the body rusty brown; belly white; a straight line dividing the colours. 4. *M. sikistan*, including the *vagus*, *subtilis*, and *betulinus* of Pallas, &c. *Sikistan*, or *subtle mouse.* Body very small; ears very large, and flapped; tail much longer than the body. 5. *M. cyanus*, Lin. *Guanque*, or *blue rat.* Blue above, whitish beneath. 6. *M. Astrachanensis*, *Astrachan rat.* Yellowish above, cinereous beneath; ears almost naked. 7. *M. rattus*, Lin. *Black rat.* Tail very long and scaly; body black above, and hoary beneath. * 8. *M. decumanus*, Lin. *Brown*, or *Norway rat.* Tail longer than the body, and scaly; body covered with strong light brown hair, white underneath. 9. *M. saxatilis*, Lin. *Rock rat.* Greyish brown, with longish tail; ears longer than the fur. 10. *M. caraco*, Lin. *Caraco*, or *American rat.* Grey; tail long, scaly, and somewhat obtuse; hind feet slightly semi-palmated. 11. *M. agrarius*, Lin. *Sitnic*, or *rustic mouse.* Tail long and hairy; body yellowish; a black stripe on the back. 12. *M. minutus*, Lin. *Minute mouse.* Rusty above, whitish beneath. 13. *M Perchal*, *Perchal rat.* Rusty brown, with the hind legs longer than the fore. 14. *M. Guyanensis*, Geoff. *Guiana rat.* The head, upper part of the body, and legs bright brown; the back of a darker shade; the belly and inside of the legs of a fine white. 15. *M Indicus*, Geoff. *Indian rat.* Yellow-grey; ears naked; tail shorter than that of the common rat 16. *M. Alexandrinus*, Geoff. *Alexandrine rat.* Somewhat tawny above, grey beneath; ears large, naked, and black. 17. *M. Cahirinus*, Geoff. *Cairo rat.* Cinereous grey above, dirty white beneath; dorsal hairs thick and bristly; tail as long as the body. 18. *M. soricinus*, Lin. *Soricine mouse.* Yellowish grey, with long snout, round furred ears, and tail of moderate length. 19. *M. humilio*, Lin. *Dwarf Cape mouse.* Front naked; hair cinereous brown; back marked with four longitudinal black stripes. 20. *M. Barbarus*, Lin. *Barbary mouse.* Brown, marked with ten pale streaks. 21. *M. Striatus*, Lin. *Streaked mouse.* Rufous brown; body marked with several longitudinal rows of white spots 22. *M. rufus Rufous rat of Paraguay* Dark rufous from the snout to the tail; flanks, sides of the neck, fore legs, and hinder parts, of a cinnamon tinge; tail short, slender, and sprinkled with short and harsh hairs.

John Vaughan Thompson, Esq. F L S. in vol xi. of the Transactions of the Linnean Society, describes an an animal which he denominates *Mus anomalus*, or the *anomalous rat.*

Azara specifies five others of this tribe, but in such an imperfect manner, that we cannot pretend to assign their proper station in the nomenclature It is not improbable also, that many more remain to be discovered.

* *M musculus.* It would be very superfluous to describe an animal, which is so familiar to the observation of almost every individual Like many of its congeners, it is extremely prolific, the female breeding at every season of the year, and bringing at a time five or six young, which, in the course of a fortnight, are capable of providing for themselves. Were it not for this ample fecundity, the race would be speedily exterminated, on account of its weakness, and the numerous and powerful enemies which it is fated to encounter; as the weasel, pole-cat, owl, &c. and especially the cat, to say nothing of the various devices of human ingenuity. The term of a mouse's life is limited to two or three years. A variety occasionally occurs that is quite white, with red eyes. Some again are nearly black, others yellowish, some spotted with white, &c.

Though this species manifests a predilection to cultivated and inhabited countries, it is also found in the solitudes of the forest, subsisting on acorns and other wild fruits of the earth. In peopled districts, it is almost unnecessary to mention that it invades the stores of the barn and granary, and all sorts of household provisions; that it even gnaws paper, and various articles of furniture; that it forms holes and passages in wood; and by the noise which it occasions when at work, sufficiently denotes the eagerness and perseverance of its efforts. More feeble, it is also more timid than the rat, seldom venturing from its hole in the day-time, and precipitately retreating into it on the slightest noise. It seems to be constantly on the alert, and is justly remarked for its sprightly and gentle manners. Indeed, when viewed without prejudice, it must strike us as an elegant little creature, with a soft and sleek skin, lively eyes, limbs delicately formed, and movements at once nimble and graceful. " I have known some ladies," observes Sonnini, " who took a pleasure in educating these little animals; and we may recollect, that Madame de Montespan, that woman celebrated for her beauty, her influence, her wanderings, and her misfortunes, soothed her sorrows, at the age of 33 by a little coach in filagree, drawn by six white mice, which sometimes took the liberty of biting her fair hand."

" Mice," continues the same interesting writer, "are easily tamed, especially such of them as, inhabiting our houses, already live in a certain degree of familiarity. Their manners are gentle; and it is alleged, that they are sensible to the harmony of musical instruments. Prisoners, abandoned and forgotten in the corner of a tower, have beguiled their stern and solitary captivity, by forming a little private society with a mouse, which, by its caresses, its nimble and playful movements, and its disinterested attachment, enabled them to endure, with more patience, the rigour of their destiny, the effect of the harshness, and often of the injustice of power."

The mouse is said to have been unknown in America before the arrival of the Europeans; but from time immemorial, it seems to have frequented the whole of Europe, the known regions of Africa, and great part of Asia. In Egypt, it has multiplied beyond calculation, insomuch that the inhabitants have ascribed its origin to the mud deposited by the Nile, and held all animals sacred which make war on the murine race. The Persians, on the other hand, regard the latter as proceeding from the evil spirit, to take vengeance on mankind; and they believe, that he who kills a mouse performs an act highly meritorious in the eyes of the Deity.

According to Pallas, the natural temperature of the mouse, which is equivalent to 107° or 109° of Fahrenheit, enables it to sustain the severest cold of the northern regions. The structure of the hair of this animal, as well as that of the rat, and probably of others of the genus is singularly curious; each hair, when microscopically examined, appearing internally divided into a kind of transverse partitions, as if by the continuation of a spiral fibre. Mice are repelled by the odour of elder, and killed by an extract of aconite, and the root of white hellebore and stavesacre, powdered and mixed with meal. Their peculiar smell is accurately represented by that of *Cynoglossum officinale*, or *hound's tongue;* and if this plant be taken when in full vigour, bruised with hammers, and laid in houses infested either with mice or rats, it will immediately induce them, it has been alleged, to shift their quarters. The curious reader will find in Gesner's Natural History, minute descriptions of a great variety of traps for the capture of mice.

Various parts and preparations of the mouse were vaunted in the pharmacy of former times; and not long ago its dung was still used in medicine, under the mysterious denominations of *musurda* and *album nigrum;* but all these pretended remedies are properly discarded from the present practice.

* *M. Messorius.* This small species is frequent in Hampshire, where it seems to have been first noticed by that entertaining naturalist, the late Rev. Mr. White of Selborne, in 1767. In some parts of England, it is called the *bean mouse*, from the great havoc which it makes among the beans when they are newly sown. It measures just two inches and a quarter from nose to tail, and the tail is two inches long. Hence the harvest mouse is regarded as the most minute of British quadrupeds. Its local range is supposed to be limited to some of the southern districts of England. For some amusing particulars relative to its habits, we have to refer our readers to White's works in natural history, and to Bingley's Memoirs of British Quadrupeds

* *M. decumanus.* This species was unknown in Great Britain till about 1730; but it has, since that period, multiplied to such a degree, that it is now much more common than the black, whose numbers it has no doubt thinned. According to Pennant, it is unknown in the country whose name it bears; and Linné omits it in the last edition which he published of his system. Brisson describes it twice under different appellations, namely, *rat du bois*, and *rat de Norvège;* and Buffon has denominated it *surmulot*, because it resembles the field-mouse, but exceeds it in dimensions. About the middle of last century, it was first observed in the neighbourhood of Paris, though it is still uncommon in many parts of the continent of Europe. In some tracts of the Russian territory, brown rats have suddenly appeared in immense swarms; and at one period their annoying multitudes compelled the Dutch to abandon the Isle of France. In that island, they may still be seen at sun-set running about in all directions; and, in a single night, they will frequently destroy a whole crop of corn. In Ireland, the brown rats have nearly exterminated the race of frogs, which the inhabitants were rather anxious to preserve, for the purpose of clearing their fields of insects, and rendering their waters more healthful. While the frogs abounded, the rats also multiplied; but since the latter have been deprived of this considerable portion of their subsistence, they, in turn, have become much less numerous. They were introduced into North America by the European settlers, and are now regarded as a serious scourge in that country.

During summer, these animals reside chiefly in holes on the banks of rivers, ditches, or ponds; but on the approach of winter they repair to the farm-houses, and enter the corn-ricks and barns, where they devour much grain, and injure even more than they devour. They likewise haunt the walls and floors of old houses, in which they often destroy the furniture. They prey on eggs, poultry, pigeons, rabbits, and game of every description; and they have even been known to gnaw the extremities of sleeping infants. There are instances of their attacking pigs put up to fatten, and eating through their thick and tough hide into the body. The males are generally much larger, and more robust and mischievous than the females. When closely pursued, they have sometimes courage to turn on their assailant, and to seize the stick, or the hand of the person who attempts to lay hold of them. Their bite is often followed by a painful swelling; and the wound, though small, does not soon heal. As they bring from ten to twenty at a litter, and breed thrice a year, the descendants of a single pair, if supplied with plenty of food, and effectually protected from enemies of every description, will amount, at the end of two years, to nearly a million of individuals. This formidable increase, however, is counteracted not only by other predacious animals, but by themselves, a large and strong rat being as much dreaded by its fellows, as the whole species is dreaded by other creatures which are its prey. The weasel, which is one of the most determined foes of the brown rats, pursues them into their holes, fights desperately with them, and often succeeds in sucking their blood; but they will turn on a small dog, and wound him severely with their bite. Buffon, who confined some pregnant females of this species in cages, observes, that, before they brought forth, they gnawed into minute pieces the interior wooden parts of the cages, and put the fragments together as beds for their little ones.

Some of the Japanese tame the brown rat, and teach it to perform many entertaining tricks: nor is this sort of murine education wholly unknown in Europe; for, not many years ago, a German had trained half a dozen brown rats to remain in a box, till he called them out of it one by one to play many antic gambols, and go through complex and various evolutions at the word of command, the exhibition concluding with a sham fight. During the first night of Crebillon's imprisonment in the castle of Vincennes, he had scarcely fallen asleep, when he felt something warm in his bed, and, supposing it to be a cat, he drove it away, and went to sleep again. Being fond of cats, he was sorry next morning that he had frightened it, as he hoped that it might afford him some amusement in solitude. Having vainly searched for it in every corner, he sat down at noon to his meagre meal, when he perceived at some distance a creature, sitting like a monkey on its hind legs, and looking quietly at him. In the darkness of his apartment, Crebillon took his visitor for the cat, and held some food to invite its approach; when, to his great astonishment, he discovered that it was a pampered rat of uncommon size. Having a great antipathy to rats, he uttered a loud shriek, and his guest instantly disappeared. The jailor, who now entered, informed him that the last person who occupied the room had rendered the rat, when quite young, so tame, that it always shared his repasts, and even slept in his bed. "I was so pleased with it," continued the jailor, "that I tried to make the rogue familiar with myself, and you shall see whether I have succeeded." So saying, he laid a piece of meat on his hand, and called, *Raton! Raton! come out, my little friend!* Raton immediately put forth his head, and, seeing his well-known benefactor, jumped on his hand, and dispatched the proffered morsel. "From that moment," said Crebillon, relating the anecdote to his friends, "Raton was my constant companion; he was restored to the possession of all the rights which he had enjoyed in the time of my predecessor, except a share of my bed; and, at my departure, I was very desirous of taking him with me to Paris; but the jailor protested against it. Nay, I cannot deny, that I parted from Raton with tears in my eyes."

Sixth family. PLANICAUDATI. Upper and lower cutting teeth sharp and bevelled; each jaw furnished with eight grinders, having either a flat crown, or transverse furrows; no cheek-pouches; tail naked, scaly, and flat, or compressed; extremities of equal length; clavicles; five toes on each foot, those of the hind feet united by a membrane, or strongly ciliated on the margin; ears short; eyes large; body covered with hair; near the anus two glands which distil a strong smelling humour.

1. Genus ONDATRA, Cuv. MUS, Lin. Grinders with transverse furrows; tail long, straight, compressed laterally; hind toes ciliated. Resident in North America.

1. *O. zibethica*, *Mus zibethicus*, Lin. *Musk rat*, *musquash*, or *musk beaver*. Characters coincident with those of the genus.

2. Genus CASTOR. Grinders with a flat crown; tail short, broad, flattened vertically; hind feet palmated. Resident in both continents.

* 1. *C. fiber*, Lin. &c. *Common beaver*. Chesnut coloured; tail flat, oval, and naked, 2 *C. Galliæ*, Geoff. *Gallic*, or *French beaver*. Four times larger than the preceding; tail proportionally shorter, and the hair coarser. 3 *C. huidobrius*, Lin. *Guillino*, or *Chili beaver*. Tail long, compressed, lanceolate, and hairy; fore feet lobed.

* *C. fiber*. See BEAVER.

Seventh family. ASCLEIDEI. Upper and lower cutting teeth broad, semi-cylindrical, and bevelled at the extremities; in each jaw four grinders, with flat or transversely ridged crowns; no cheek-pouches; tail short, weak, or wanting; the posterior a little longer than the anterior extremities; no clavicles; four toes on the fore feet; only three on the hind; armed with claws resembling hoofs; ears round. Resident in the southern countries of the new continent.

1. Genus HYDROCHÆRIS, Cuv. CAVIA, Lin. Grinders furrowed, as if formed of transverse vertical laminæ, soldered together; no tail.

1. *H. capybara*, *Cavia capybara*, Lin. *Capybara*, *river cavy*, or *thick-nosed tapir*. Hind feet palmated. * 2. *H. cobaya*, *cavia cobaya*, Lin. *Variegated*, or *restless cavy*, or *Guinea pig*. Body variegated.

* *H. cobaya*. The popular denomination of *Guinea pig* is obviously incorrect, both because the animal is not a native of Guinea, and because it does not belong to the porcine tribe. This species is so liable to diversity of colouring, that scarcely any two individuals exactly agree in this respet. Some are almost entirely white, others spotted with black and white, with black and fawn colour, with yellow, tawny, &c. The body is short, and thicker than that of the rabbit; the neck is not distinguishable from the head and trunk; the ears, which are large, naked, and transparent, are in a great measure concealed by the hairs on the upper part of the head; the eyes are round, large, and prominent; the head and nose resemble those of the hare and rabbit; the teeth are similar to those of the rat, but they are placed obliquely outwards in the upper, and obliquely inwards in the lower jaw; and the hair is long, hard, and smooth.

The variegated cavy is indigenous to Brazil, and other countries of South America; but we have few authentic notices of its manners in a wild state. As it is, however, easily domesticated, and can bear the temperature of many of our European countries, its habitudes in confinement are pretty generally known. Among the most remarkable of these, we may reckon its precocity and fertility; for, though it attains not its full growth till eight or nine months, it is capable of propagating in five or six weeks after birth. The female goes only three weeks with young; her first litter consists of four or five, her second of five or six, and her subsequent ones of seven or eight, or even sometimes of ten or eleven. The dam gives suck only for twelve or fifteen days, and chases away her young if they remain longer by her; or, if they prove refractory, she permits the male to abuse and kill them. Her parental attachment, indeed, seems to be much weaker than in most other species; for she will often suffer her young to be taken from her, and even devoured as soon as they are born, without betraying the least concern. As she breeds once in the two months, it has been calculated that a single couple may prove the source of one thousand individuals in the course of a year. To check this excessive fecundity, nature has provided that many of them should fall a sacrifice to cold and moisture, to the feeble and short-lived affection of their parents, to their quarrels with one another, and to their incapacity of defending themselves against cats and other beasts of prey. Their life is an almost incessant round of eating, sleeping, and re-producing their kind. Buffon asserts, that though they never drink, they frequently urinate. But this is not strictly correct; for they are very fond of milk, and, in default of it, have recourse to water. They readily feed on all sorts of herbs; but prefer parsley, and the tops of carrots, even to bread or flour. They are also very fond of apples and other fruits. They eat precipitately like rabbits, and very often, but little at a time. Their usual cry resembles the grunting of a young pig; but they also express pleasure or pain by appropriate sounds. They are very susceptible of cold, and will press together to avoid its effects. Though naturally tame and gentle in their deportment, they are incapable of strong attachment. They affect dark and intricate retreats, and seldom venture out of concealment when danger is at hand. They are at great pains to keep themselves and one another clean, frequently licking and smoothing their own and neighbour's fur. With scarcely sufficient courage to defend themselves against the attacks of a mouse, their animosities against those of their own species are obstinate and violent, and generally originate in a desire of possessing the warmest corner, or the most agreeable food. Their mode of fighting is very singular; for one of them, seizing the neck of its antagonist with its teeth, attempts to tear off the hair, while the other turns its posteriors to the aggressor, kicks up behind like a horse, and scratches his rival's flanks to the effusion of blood.

Though frequently used as an article of food, the flesh of these animals is not in general esteem for its delicacy; yet, by a proper admixture of dry and succulent food, they might, it is presumed, be rendered more deserving of a place at the table.

2. Genus Cavia, Lin. &c. Grinders with a flat crown, groved on the sides; tail short.

1. *C. paca*, *Spotted cavy*. Sides striped with yellow spots. 2. *C. aguti*, Lin. *Agouty*, or *long-nosed cavy*. Body tawny brown; abdomen yellowish. 3. *C. acouschi*, Lin. *Acouschy*, or *olive cavy*. Body olivaceous. 4. *C. aperea*, Lin. *Rock cavy*. Tawny ash above, white beneath. 5. *C. cristata*, Geoff. *Crested cavy*. Hair behind the head tufted. 6. *C. quouya*, *Quouya cavy*. Hair on the back long and dark; the rest also dark, but sprinkled with reddish spots. 7. *C. viscaccia*, *Lepus viscaccia*, Lin. *Viscaccia*, or *Peruvian hare*. Brownish, with bristly tail. 8. *C. pampa*, *Pampa cavy*. Bright brown above, white beneath.

Eighth family. Leporini. Cutting teeth bevelled, the upper double; *i. e.* each having a smaller subsidiary one behind; from five to six grinders on each side in both jaws, and formed of plates, as if soldered; tail short, or wanting; the hinder a little longer than the fore extremities; a very large cæcum, furnished through its external length with a spiral membrane.

1. Genus Lepus, Lin. &c. The hind considerably longer than the fore legs; ears long; tail short; clavicles weak, and almost cartilaginous; five toes on the fore feet, four on the hind. Resident in both continents.

* 1. *L. timidus*, Lin. &c. *Common hare*. Tail short; ears longer than the head, and tipped with black. * 2. *L. cuniculus*, Lin. &c. *Rabbit* or *coney*. Tail short; body brown; tips of the ears black; hind legs shorter than the body. * 3. *L. variabilis*, Lin. &c. *Varying hare*, *alpine hare*, of Pennant's British Zoology. Body white in winter, except the tips of the ears, which remain black. 4. *L. Americanus*, Lin. *American hare*. Tawny grey above, white beneath; hind legs longer than the body, and the ears and tail tipped with grey. 5. *L. Ægyptius*, Geoff. *Egyptian hare*. Ears long and broad; legs brown; hair on the back light grey. 6. *L. tolai*, Lin. *Baikal hare*. Pale brown, with the upper edges of the ears black. 7. *L. tapeti*, *Brazilian hare*. Tailless; brown above, white beneath; with a white collar round the neck.

* *L. timidus*. Without entering into a minute description of an animal so generally known, we shall merely state a few particulars relative to its structure and appearance, and thus have room for more detail concerning its history and manners. The inside of the mouth is furnished with hairs; the nose and tongue are very thick; the upper lip is cleft to the nostrils, which seem to unite, and to form a single opening; the eyes, which are very prominent, are furnished with a nictitating membrane; the feet are covered beneath, as well as above, with fur; the heart is proportionably large; and the cæcum about six times as large as the stomach.

In the Mosaic law, the hare has been classed with ruminating animals; a circumstance which leads Scheuzer to suspect that the passage has been misinterpreted. Be this as it may, the hare, according to the most recent physiological observations on the subject, though its stomach is differently organized from that of the ox, is an occasional and partial ruminant, and is not, therefore, erroneously associated with animals which chew the cud. The absurd notion of the ambiguity and transmutation of sex in this quadruped, has doubtless arisen from certain peculiarties of conformation, which puzzle an ordinary observer to discriminate between the male and female.

There is scarcely a country in which the hare is not to be found, from the torrid zone to the vicinity of the poles. In hot regions, it is usually of a smaller size than in the cooler quarters of the globe. A very small breed, however, has been observed on the island of Islay; and a very large one on the Isle of Man, where individuals have been taken that weighed 12 pounds. Examples occur in England, of hares weighing from 10 to 11 pounds; but from 7 to 8½ is the more common weight. Hares, in their natural state of freedom, are never fat; but when tamed and fed in the house, they sometimes die of excessive obesity.

The kind provisions of nature for the preservation of the leporine race are many and wonderful, and afford a striking proof, among thousands which might be produced, of that system of compensations, that balancing of perfections and defects, that equalizing of the quantity of life and destruction, on which the continued existence of the respective tribes of animals depends. If the hare is, on the one hand, exposed to the attacks of almost every beast of prey, it is, on the other, abundantly fruitful; and, if often pursued, it is also furnished with various sources of evasion and escape. Its ears are so contrived, as to convey even remote sounds from behind: the eyes are so situated, as to enable it, when at rest on its seat, to observe without difficulty, and even without much motion of the head, a whole circle; and though it sees imperfectly in a straight line forwards, it can direct its vision to whatever threatens it in the way of pursuit; and the eyes are never wholly closed during sleep. From the extraordinary muscularity of its limbs, it can sustain the fleetness of its course for a considerable time. while the greater length of the hinder legs gives it such a decided advantage in ascending, that, when started, it always makes to the rising ground. Its habitual timidity, and perpetual apprehension of danger, preserve it lean, and in a condition the best adapted to profit by that speed which forms its security. The thick hairy protection of its feet also gives it, in dry or frosty weather, an advantage over the dog which pursues it. Its near approach in colour to the soil, often conceals it from the sight of man and predacious animals; and, in northern countries, its fur frequently becomes white in winter, so as hardly to be distinguished from the surrounding snow. As if conscious of its resemblance to the earth on which it treads, it has often been known, when close-pressed by the hounds, to squat behind a clod, and suffer the dogs to run over it, which they no sooner do, than it instantly takes a contrary direction, and thus deceives them. As it possesses the sense of smell in a pre-eminent degree, it is often aware of the presence of an enemy, before it can ascertain its danger by sight. The doublings of its course are familiar to every sportsman; and though in some respects its sagacity seems to be a fault, especially in exhausting its strength in the early part of the chase, and in returning to its resting place by the same paths, it has been frequently observed to have recourse to stratagems, which, in the human being, would bespeak not only presence of mind, but a prompt and practical application of the reasoning principle.

The multiplication of hares, if undisturbed, would prove greater than that of most quadrupeds; because they are capable of breeding at all seasons, and from the first year of their existence, while the term of gestation exceeds not thirty-one days. The hunters allege, that when the produce consists of more than one, each levret is marked with a star-like appearance on the forehead, which usually disappears at the first moulting, but sometimes continues to a more advanced period. Sir Thomas Brown, in his *Treatise on Vulgar Errors*, asserts, from his own observation, that female hares frequently have in their ovaries, at the same time, young ones of different ages, and that, after those which are mature are brought forth, there will remain others which are very far from the term of their exclusion. Buffon confirms this phenomenon of superfœtation in the hare, and has explained it on anatomical principles. The observation is, however, at least as old as Herodotus. The breeding-place is usually under a tuft of grass, a high brake, a bush of heath, brush-wood, standing corn, &c. The dam suckles her young about twenty days, after which they separate, and procure their own food, making their forms at sixty or eighty paces from each other: so that, when we meet with one young hare, we are pretty sure of finding more within a small distance. The hare arrives at maturity in one year, and is supposed to live seven or eight; but it is presumed, that a small number, comparatively, are allowed to die of old age: for dogs of all kinds pursue them by instinct; the cat and the weasel tribes, are constantly lying in ambush, and practising their wary arts to seize them; while birds of prey are still more formidable enemies, as against them no swiftness can avail, nor retreat afford security; and, lastly, man, far more powerful than all, sacrifices great numbers either to his subsistence or to his pastime.

The favourite residence of the hare is in rich, and somewhat dry and flat grounds; and it is rarely observed in very hilly or mountainous situations; neither is it often found in places much exposed to the wind, especially when it blows from the north or south. Shepherds and hare-finders, moreover, remark, that the hares on the downs have a variety of seats, which they shift from time to time, as the weather directs, generally ascending to the more elevated grounds when rain prevails. They feed on various vegetables, but seem to prefer those of a milky and succulent quality, and to be very partial to pinks, carnations, parsley, birch, and laburnum. During winter, they will prey on the bark of almost every tree; and they are often very injurious to young plantations. Their cry, which has been compared to that of an infant, is seldom heard, except in cases of surprise or distress. In some countries where they abound, they are taken by a call, which is a squeaking sound, first slow, and then quicker, and imitative of that between the male and the female.

Although not very susceptible of strong attachment, the hare is naturally of a gentle disposition, and, when taken young, may be tamed without much difficulty. Shy and timid as it undoubtedly is in its native haunts, yet, when domesticated, it often assumes a forward and even petulant demeanour. In respect of temper and talent, however, a very marked diversity probably obtains among different individuals, as has been finely exemplified by Cowper, the poet, in his account of three which he watched himself. Similar instances might be quoted from Sonnini, Townson, Borlase, &c.

The flesh of the hare was reckoned a great delicacy among the Romans, and, in Martial's estimation, was superior to that of all other quadrupeds. From an allusion in the second satire of his fourth book, we may infer, that Horace regarded the *wing* as the part in highest request among his countrymen. The fur forms a considerable article in the manufacture of hats; and, as this country cannot supply a sufficient number of skins for the purpose, large quantities are yearly imported from Russia and Siberia. Austria annually furnishes a million, and Bohemia 400,000 of these skins. In Wallachia, they constitute a considerable article of trade; and, in the Crimea, they are sold at a very reduced price, and converted into warm fur clothing.

Though no animal can appear less formidable or repulsive to a human being than a timid levret, it is somewhat remarkable, that the brave Duc d'Epernon, from one of those constitutional antipathies for which it is so difficult to account, always fainted at the sight of one.

* *L. Cuniculus*. A practical eye is seldom at a loss to distinguish between a rabbit and a hare; and yet the difference is not easily expressed in terms of precision. The Hon. Daines Barrington has proved, that the criteria selected by Linné are incorrect; neither do we believe, that the proportions stated by that gentleman himself are infallible, as they have been found to vary in the same individual at different periods of its age. A more decided proof of a distinction of species is, that they do not sexually intermingle. Buffon's experiments on this point seem to be perfectly satisfactory. We are indeed aware, that the Baron de Gleichen is disposed to question their accuracy, and asserts, on the testimony, he says, of an ocular witness, that the existence of a hybrid issue from the female hare and wild rabbit is not uncommon in Hoching, a district of Polish Prussia. But we could have wished that M. de Gleichen had condescended to name this ocular witness; for we cannot find that any naturalist or traveller of respectability has adverted to the circumstance; and, if such a mongrel breed existed, we can assign no reason for its limitation to an obscure portion of Polish Prussia. It has, on the contrary, been generally observed, that a natural and strong antipathy, which

even domestication can seldom obliterate, subsists between the rabbit and the hare. We may add, that their general habits are also different, and that the flesh of the former is whiter, less juicy, and less highly flavoured than that of the latter.

The ordinary and predominant colour of the rabbit, in its wild state, is grey, or rather a mixture of tawny, black, and cinereous. The upper part of the tail is black, and the belly and under part of the tail are white. Black, white, and intermediate varieties occur, especially among domesticated individuals. The soles of the feet are covered with rufous hairs.

The rabbit naturally affects warm and temperate latitudes, and is somewhat partial to the sandy downs of sea-shores. Pliny mentions Greece and Spain, as the countries of Europe in which it formerly resided. Both he and Varro relate, that an entire town in Spain was overturned by the incredible number of rabbits which lodged under its foundations; and we learn from Strabo, that the inhabitants of the Balearic Islands, apprehensive that their country would be rendered desolate by the extraordinary multiplication of these creatures, sent deputies to Rome, to implore military aid against this novel description of enemy. In subsequent periods, the Spaniards thinned their numbers by means of ferrets, imported from Africa. According to Spallanzani, when the crops were wasted in Baziluzzo, one of the Lipari Islands, by an unusual increase of rabbits, the natives had recourse to large importations of cats, which soon destroyed them. The species is supposed to have been originally confined to Africa, and to have been afterwards diffused over the warmer and milder portions of Europe and Asia. Introduced into America, it has there found a climate congenial to its constitution, and has rapidly multiplied, especially in the southern countries of that continent. In Sweden, it ceases to thrive in the open air, and requires the warmth of confinement.

Rabbits are capable of breeding when only five or six months old; their term of gestation is thirty or thirty-one days; and a vigorous female will bring about eight young seven times in the course of a year; so that in the course of four years, her progeny, in theory, should amount to 1,274,840 individuals. But, in the first instance, we cannot average the amount of fertility at the *maximum*; and, secondly, as we observed in the history of the hare, the race is obnoxious to the attacks of men, and of various predacious animals. Before the dam brings forth, if she does not find a hole suited to the purpose, she digs one, not in a straight line, but in a zig-zag direction, enlarging the bottom of it every way, and pulling from her own body a quantity of hair, with which she makes a warm and comfortable bed for her young. During the whole of the first two days, she never leaves them, except when pressed by hunger, and then she eats with surprising quickness, and immediately returns. She always conceals her charge from the male, lest he should devour them; and, for the same reason, when she ventures abroad, she covers up the hole so carefully, that its place is scarcely perceptible. In this manner she continues her attentions for about a month, when the young are able to provide for themselves. The ordinary term of a rabbit's life is eight or nine years. It seeks to avoid moisture, and delights in a dry sandy soil. On a dead level it finds it difficult to make its burrow, as the mould must be thrown upward to the surface; whereas, on the side of an eminence, the declivity affords a ready fall for the earth, and the work is down hill. As the rabbits on the island of Sor, near Senegal, do not burrow, we are tempted to suspect, that the digging of holes for themselves, in colder climates, is an acquired art, prompted by circumstances. This conjecture will appear still more probable, when we reflect, that domestic rabbits never give themselves the trouble of digging, and that, when a warren is attempted to be stocked with a domestic breed, they and their offspring remain on the surface, and never begin to make holes for their protection, until they have endured many hardships, and passed through several generations. Dr. Darwin has observed, that as rabbits cannot articulate sounds, and are formed into societies that live under ground, they have a very peculiar method of giving alarm: for, when danger is threatened, they thump on the earth with one of their hinder feet, and produce a sound which may be heard a great way by animals near the surface. The females are the most vigilant sentinels, and remain without till all their companions have entered their holes. Though habitually concealed under a thick covering of earth, these animals are very sensible to approaching changes of the weather, and will seldom go abroad in the day-time, unless it be calm and settled: while their presentiment of a storm in the night-time impels them to rush out, and quickly devour their stated fare, that they may be safely housed again before they are overtaken by the blast.

In stocking a warren, it is customary to make artificial burrows, of the diameter of the animal's body, with augers, for defending the rabbits against cold and vermin, till they make holes themselves. The too great succulence of their diet should be corrected by a due mixture of hard and dry food, as hay, barley, oats, toasted bread, &c. to prevent a scouring, which often proves extensively fatal: the same precaution will often save them from dropsy. Cleanliness, and a free circulation of wholesome air, are the best preventatives of a pining sickness, accompanied with an infectious itch, to which the young are otherwise subject. A dry regimen will in general remove the pustules which sometimes cover their liver; and fresh air and litter are recommended for a disease in the eyes, which is apt to carry off the females after they have suckled their young.

The skin of the grey rabbit is cut from the pelt, as a material in the manufacture of hats, and that of the silver-haired is dressed as fur, and consequently fetches a higher price. The hair has been frequently converted into gloves and stockings, of a light, fine, and downy texture, and the skin itself into glue of uncommon purity and tenacity.

* *L. variabilis.* This species is generally smaller than the common hare, with which, however, it has been known, though rarely, to intermingle, limiting its residence chiefly to elevated situations, between 1500 and 2000 feet above the level of the sea, in the northern parts of the globe, as in the mountains of Scotland, Lapland, Norway, Russia, Siberia, Kamtschatka, and some districts of Canada. Its colour, in summer, is a tawny grey, and in winter entirely white, except the tips of the ears and the soles of the feet, which are black; but the latter are very thickly covered with a yellowish fur. The alteration of colour begins in September, and first appears about the neck and rump: in April, the white gives place to grey; but, in the polar parts of Greenland, the white is permanent, like the general livery of the country. The internal heat of this species, even during the

most intense cold, is from 103° to 105° of Fahrenheit; and its fecundity, even in the most rigorous climates, is truly astonishing. It is easily tamed, very sprightly and frolicsome, and particularly fond of honey and carroway comfits. In its wild state, it subsists, in winter, on *agarics*, kernels of *Pinus cembra*, &c.; and, in summer, it manifests an evident partiality to the bark of the dwarf willow. The flesh is drier and less savoury than that of the common hare.

2. Genus LAGOMYS, Cuv. LEPUS, Lin. Hind feet nearly equal in length to the fore; four unguiculated toes on each foot; ears short; tail wanting; clavicles robust. Resident in the old continent.

1. *L. Alpina*, *Lepus Alpinus*, Lin. *Pika*, or *Alpine hare*. Ferruginous, with rounded ears, and brownish feet. * 2. *L. pusilla*, *Lepus pusillus*, Lin. *Soulgan*, or *Calling hare*. Body brown, mixed with grey; ears somewhat triangular, and edged with white. 3. *L. ogotona*, *Lepus ogotona*, Lin. *Ogoton hare*. Body pale grey; ears oval, somewhat pointed, and of the same colour with the body.

* *L. pusilla*. This singular animal, and its two congeners, exhibit an intermediate appearance between the hare and the rat, whence their more appropriate generic appellation adopted by Cuvier. The soulgan is one of the prettiest little quadrupeds that inhabit the wastes of Tartary. It is of the size of the water-rat, and weighs from three ounces to four and a half, according to the season. The fur, which is thick and very soft, consists of two kinds of hair, the one very long, and the other shorter and woolly.

These creatures dig pretty deep burrows, with one or more entrances, in places covered with brush-wood, and abounding in plants; and seldom venture abroad till night, when they roam in quest of food. They sleep with their eyes open, and seem to discern objects during the night. Though seldom seen, they often betray their haunts by their voice, which is heard after sunset, and early in the morning; being repeated at intervals, three, four, or six times, much resembling that of a quail, and loud enough to be heard at a considerable distance. They never call in the day-time, except in stormy or very cloudy weather, when their note is often mistaken for that of some bird. They are also traced by their dung, which they range in small heaps near the entrance of their dwellings. Their food chiefly consists of gramineous and succulent plants, of the leaves and branches of trees, the tender bark of shrubs, &c. Except in spring, or early in summer, when they pair, they lead a solitary life, but are nevertheless very gentle, and so easily tamed, as to become quite familiar with a person in the course of a day. One of them, when sitting, just fills the hollow of the hand. Its pace is a kind of leaping motion, but not very quick; nor does it run well, on account of the shortness of its legs. The female produces five or six young, which rapidly arrive at maturity. In order to support the rigours of its native climate, this little quadruped, which does not hybernate, has need of a very considerable degree of internal heat; and we find, accordingly, that it corresponds to 104° of Fahrenheit's scale.

Ninth Family. HYSTRICINI. Muzzle short; upper and lower cutting teeth broad, simple, and bevelled; eight flat-crowned grinders in each jaw; extremities nearly equal in length; five toes on the hind feet; four, and the clawless rudiment of a thumb, on the fore feet; body covered with prickles, which are often very long; ears short; cæcum large.

1. Genus HYSTRIX, Lin. &c. Tail short, and not prehensile. Resident in both continents.

* 1. *H. Cristata*, Lin. *Crested*, or *Common porcupine*. Head crested. 2. *H. fasciculata*, Lin. *Brush-tailed*, or *Malacca porcupine*. Tail ending in a tuft of flattened bristles. 3. *H. dorsata*, Lin. *Canada porcupine*. Spines short; fur very long; back furnished with a ridge of spines.

* *H. cristata*. (Plate CCCLVI. Fig. 27.) The name of this species in English, and in most of the languages of Europe, is probably founded on its grunting noise; for scarcely in any other respect does it resemble the hog. Its ordinary length is about two feet and a half from the head to the end of the tail. The upper parts of the body are covered with hard and sharp spines, some of which measure from nine to fifteen inches in length, all being complete quills, variegated with alternate black and white rings, slightly attached to the skin, and deciduous in the moulting season. The animal can raise or depress them at pleasure, but is incapable of darting them with force or effect to any distance. The head, belly, and legs, are covered with strong dusky bristles, intermixed with softer hairs; which last, on the top of the head, are very long, and bent back, like a ruff or crest. The tail is covered with short, and rather flattish quills, which are often abrupt, or truncated at the extremity.

The porcupine is a native of Africa, India, the Indian islands, Persia, and some of the warmer countries of Europe, as Italy and Spain. During the day, which is the period of its repose, it inhabits subterraneous retreats, and, in the night, it makes its excursions for fruit and vegetables, which constitute its principal food. It is particularly fond of *Calla Ethiopica*, and of boxwood, though the juice of either the root or leaf of the former is so acrid, as to blister any part of the human body to which it is applied. Although capable of enduring protracted hunger, without apparent inconvenience, it eats with every symptom of a keen appetite. The ordinary term of its life is fourteen or fifteen years. The female goes with young about seven months, and produces one or two at a time, which she defends with the utmost resolution against all assailants. When irritated, the porcupine stamps forcibly on the ground, shakes its quills, particularly those about the tail, and exerts its grunting voice. In its general manners, however, it is gentle and inoffensive, never acting as an aggressor; and, when pursued, climbing into the first tree within its reach, where it remains till the patience of its adversary is exhausted. Yet, if roused to self-defence, even the lion scarcely dares to attack it. Its prickles inflict severe, though not poisonous wounds; and a dog which has once come in contact with them, will not return to the charge.

In the eleventh volume of the *Journal de Physique*, the Comte de Turin has communicated some interesting observations on two individuals of this species, which he kept in confinement, and which propagated in that state. In opposition to a common notion, that the young are born without quills, he mentions, that in the specimen which he preserved in spirit of wine, and which was still-born, the quills were already two inches in length, and variegated with white and black, as in the adults. The living young one, while yet attached by the umbilical chord to its mother, erected its little bristles, if approached by the hand; and, after the fourth or fifth day, could not be touched without great precaution.

In the stomach of the porcupine are frequently found bezoardic concretions, which sometimes attain to the size of a goose's egg. The flesh of this species is very luscious, and soon palls on the appetite.

2. Genus Coendu, La Cepede; Hystrix, Lin. Tail very long and prehensile. Resident in the new continent.

1. *C. prehensile*, *Hystrix prehensilis*, Lin. *Prehensile tailed*, or *Brazilian porcupine*. Spines short; tail half naked.

Order V. MONSTREMOUS, Cuv. and Geoff.

Lips wanting; toes with claws; a common vent; marsupial bones; no uterus, properly so called; penis imperforate; teats either wanting, or not hitherto observed; a small double cæcum; a bone analogous to the *fork* in birds.

In this place we purposely omit inserting the genus *ornithorinchus*, because the extraordinary species which belongs to it is now presumed to be *oviparous*. See Ornithorinchus.

1. Genus Echidna, Cuv. Head terminating in a long tubular snout; palate furnished with six rows of small bony teeth; tongue very long and extensile, as in the ant-eaters; five toes on each foot, armed with very strong, channelled, and hooked claws, adapted to digging the earth; body covered with very strong, conical spines, sometimes intermixed with hairs; tail a simple tubercle; an additional claw on the hind feet of the males.

* 1. *E. aculeata*, *E. hystrix*, Geoff. *Myrmecophaga aculeata* of Shaw and others. *Aculeated*, or *Porcupine ant-eater.* Bristling with prickles. 2. *E. setosa*, Geoff. *Silky echidna.* Covered with long bushy hair, among which small prickles are interspersed.

* *E. aculeata.* This singular quadruped, a native of New Holland, is about a foot in length. All the upper parts of the body and tail are thickly coated with strong and very sharp spines, of considerable length, and resembling the porcupine's quills, except that they are thicker in proportion, and, instead of exhibiting alternations of black and white, are mostly of a yellowish-white, with black tips; the head, legs, and all the under parts of the body, are of a deep brown, or sable, and thickly coated with strong, close-set, bristly hair. In its manners, it is said to resemble the genuine ant-eaters. When molested, they burrow with great strength and despatch; during which exertion their body is drawn out in a surprizing manner; whereas, when they are undisturbed, they have a short and plump aspect.

Order VI. EDENTULOUS, or TOOTHLESS.

Cutting-teeth, tusks, and sometimes also the grinders wanting; no cloaca; toes furnished with very long and very strong claws.

A. Head elongated; muzzle conical.

First Family. Myrmecophagæ, or *Ant-eaters.*

Head more or less lengthened; opening of the mouth very small; no teeth of any description; tongue very long, slender, and extensile; body covered with hairs, or scales; claws strong, recurved, and sharp; tail very long; ears very short; a small double cæcum as in birds.

1. Genus Manis, Lin. &c. Head elongated; body covered with large, hard, triangular scales, with sharp edges, placed on one another like tiles on the roof of a house; tail very long and robust, not prehensile, and also covered with imbricated scales; no clavicles; toes armed with strong claws, of moderate length, and not compressed; no external ears. Resident in the hottest countries of the old continent.

1. * *M. pentadactyla*, Lin. &c. *Short-tailed manis*, or *pangolin.* Feet five-toed. 2. *M. tetradactyla*, Lin. &c. *Four-toed*, or *long-tailed Manis*, or *phatagin.* Feet four-toed.

* *M. pentadactyla.* (Plate CCCLVI. Fig. 28.) The form of this quadruped partakes, in some measure, of that of the crocodile. Its length, including the tail, is from six to eight feet. The eyes are placed high in the head; the ears are rounded and naked, somewhat resembling those of the human species. The colour of the whole animal is a very pale yellow-brown; and the surface is glossy. It inhabits woods and marshy places in Africa, and various regions of the East Indies; feeding chiefly on ants, which it catches by laying its long tongue across their paths. It walks slowly, and, if pursued, it rolls itself up in its coat of mail, when even the leopard attacks it in vain. It endeavours to elude the vigilance of man by retiring into holes in the rocks, or into burrows of its own excavation, where the female produces and suckles her young. The negroes despatch the pangolin with blows of a stick, sell the skin to Europeans, and eat the flesh, which is white and savoury. In the stomach of an individual of this species were found a great many small stones, which the animal was supposed to have swallowed for the purpose of aiding digestion.

2. Genus Myrmecophaga, Lin. &c. Head much prolonged; body covered with hair; tail very long, and, except in one species, prehensile, furnished with clavicles; the claws very strong, compressed, sharp-edged, and crooked, varying in number from two to four for the fore feet, and from three to five for the hind; external ears very short. Resident in the south of the new continent.

* 1. *M. jubata*, Lin. *Great ant-eater*, or, as it is sometimes more improperly denominated, *great ant-bear.* Four toes on the fore feet, five on the hind; tail with long hair, like a horse's mane. *M. tetradactyla*, Lin. *Midde ant-eater*, or *tamandua.* Four toes on the fore feet, five on the hind; tail half naked, and prehensile. 3. *M. nigra*, Geoff. *Black ant-eater.* The characters correspond with those of the preceding species, but the body is of a deep black. 4. *M. didactyla*, Lin. *Little ant-eater.* Two toes on the fore feet, four on the hind.

* *M. jubata.* (Plate CCCLVI. Fig. 29.) There is a black stripe on the breast and flanks; the hind legs are blackish, the fore legs whitish, with a black spot about the middle; the long tongue, when not protruded, is folded up in the mouth; the body is nearly four feet in length, exclusively of the tail, which is two feet; and the hairs which cover the whole are not cylindrical throughout, but flattened towards the extremity, and feel hard and dry like hay.

The great ant-eater is a native of Brazil or Guiana, where it lives chiefly in the woods and savannahs that overspread the uncultivated portions of these countries. Between Paraguay and the Plata it is of less frequent occurrence. Though it runs slowly, its legs are so strong and muscular, that few animals can rescue themselves from its gripe. For the most part it shuns contention; but if attacked and irritated, it combats with great fierceness and obstinacy. It is not unfrequently observed to swim across rivers with considerable ease, throwing its tail over its back. It likewise climbs trees in quest of aphides and wild honey. But its principal mode of procuring food deserves to be particularized. Some parts of South America abound with termites, or white ants, which build hills five or six feet high. On approaching one of these common dwellings, the creature creeps slowly forward, taking every precaution to keep itself concealed, till it arrive at the proper distance from the place where it intends to make its repast. There it scratches the ground with its claws, to induce the ants to assemble, and lying close at its length, protrudes its red cylindrical tongue, which is sometimes two feet long, across the path of the bustling and unsuspecting insects, which, taking the instrument of their destruction for a bit of flesh, or a worm, crawl on it in great numbers, and are entangled in the viscid fluid which adheres to it, when their deceiver, abruptly drawing them into its mouth, instantly devours them, still retaining its position, and repeating the same stratagem with such astonishing rapidity, that it will retract its loaded tongue twice in a second. Should the unfavourable state of the weather, or the unseasonableness of the hour, cause the ants to remain in their habitation, this animal overturns the hill, or digs holes in it with its strong claws, when, thrusting its long tongue into the retreats and passages, it withdraws it loaded with prey, till it has satisfied the cravings of appetite. It then returns to its hiding place, and gives way to indolent repose, until the calls of hunger again compel it to move abroad. When asleep, or exposed to a heavy shower of rain, it covers itself with its tail, in the same manner as the squirrel; at other times it trails that appendage along, and sweeps the gravel; and, when irritated, it frequently and abruptly tosses it about, or makes it stand erect. It is capable of supporting long abstinence, often sleeps during the day, and goes abroad in the night-time. Part of the water which it takes up in drinking is discharged from the nostrils. The female, at a birth, brings only one young, which does not attain maturity till its fourth year, and which the dam often carries on her back. In a domestic state, this species will pick up crumbs of bread, and little bits of flesh. Though easily taken and tamed, it proves rather a curious than an interesting companion. The flesh, though rank, is eaten by the Indians.

Second Family. ORYCTERII. Head more or less elongated; gape larger than in the preceding family; flat-crowned grinders and tusks, but the cutting teeth wanting; body invested with a hard skin, covered with hair, or enveloped in a bony crust; claws strong, short, not particularly sharp, but fitted for excavating the soil; ears long; tail very long; cæcum wanting; intestines with several strangulations.

1. Genus ORYCTHEROPUS, Geoff. MYRMECOPHAGA, Lin. Body covered with hair; head much elongated; snout terminated by a cartilage; six grinders in each jaw; tongue long and extensile; four toes on the fore feet, and five on the hind, furnished with strong, long, and broad claws, rounded at their extremities, and a little bent, those of the hind feet the longest. Resident in Southern Africa.

1. *O. capensis*, Geoff. *Myrmecophaga capensis.* Lin. *Cape orycterophus*, or *ground hog.* Tail shorter than the body, and attenuated towards the tip.

2. Genus LORICATUS, Desm. DASYPUS, Lin. Head conical, and moderately lengthened; body covered with a scaly crust, composed of several distinct pieces, in the form of moveable zones, round the middle of the body: no cartilage at the snout; tongue short, and not extensile; four grinders on each side of the jaws; five claws on the hind feet, and sometimes only four on the fore feet. Resident in South America.

In this tribe the legs and feet are generally very large in proportion to the size of the body, and hence its Linnean designation. The term adopted by Desmarest, as also the more familiar names of *armadillo, iron pig*, *shield hog*, &c. allude to their crustaceous or shelly covering, and their hog-like form. They are a peaceful and harmless race when unmolested, and feed not only on roots, succulent vegetables, and fruits, but also on worms, water insects, eggs, small birds, fish, vipers, lizards, &c. They will also eat flesh when they can procure it, not excepting corpses, as often as they can get at them. They are said to drink frequently, grow very fat, and, notwithstanding their musky odour, are much esteemed as a delicate article of food. Their most ordinary motion is a quick walk; but they are incapable of running, leaping, or climbing into trees. If pursued by dogs in open fields, they either instantly make towards their holes, if the latter happen to be near them, or form a new retreat on the spot, which their habits of burrowing enable them to effect with wonderful expedition. If, when entering into the earth, they are caught hold of by the tail, their resistance is so obstinate, that they will sometimes leave that member in the hands of their pursuers. To prevent which, the Indian hunter has recourse to artifice, and, by tickling the animal with a stick, cajoles it to its ruin. As a last resource, it will fold itself up, and will sometimes escape, by rolling over the edge of a precipice, and falling to the bottom unhurt. The most successful mode of catching them, is by snares laid for them by the sides of rivers, and such marshy places as they usually frequent. There are several of the species which seldom stir abroad except during the night.

It may be proper to remark, that, in their classification of this genus, authors differ in their enumeration of the bands, either from the inattention of draughtsmen and engravers, or from a difference in the mode of reckoning these distinctive characters. In some cases, indeed, the latter are so disposed, as not to be readily discriminated from the scaly divisions on the fore and hind parts of the body, which also present a zone-like appearance.

1. *L. giganteus*, Desm. *Dasypus giganteus*, Geoff. *Largest armadillo.* Nearly five feet long, including the tail; bands from twelve to fourteen; scales almost square. 2. *L. flavimanus*, Desm. *Dasypus sexcinctus*, Lin. *Six-banded*, or *yellow-banded armadillo.* Six or seven bands, and all the feet yellow. 3. *L. tatouay*, Desm. *Dasypus duodecim-cinctus*, Lin. *Twelve-banded armadillo*, or *tatouay.* With twelve bands, and few scales. 4. *L. villosus*, Desm. *Hairy armadillo.* Six or seven bands, covered with brown hairs, of which some are two inches long. 5. *L. niger*, Desm. *Black armadillo.* Seven, eight, or nine bands; body black. 6. *L. hybridus*, Desm. *Hybrid armadillo.* Like the preceding, but the legs proportionably shorter. 7. *L. Pi-*

chiy, Desm. *Pichiy armadillo.* Front shield flat; hind shield composed of transverse rows, consisting of small irregular pieces. *L. matacus*, Desm. *Dasypus tricinctus*, Lin. *Three-banded armadillo*, or *tatou apara.* With three moveable bands.

B. Head short, muzzle round.

Third family. Tardigradi. Cutting teeth wanting; two pectoral teats; stomach divided by strangulations; clavicles and a cæcum; claws very long and very stout, but varying in number; no apparent tail. Resident in South America.

1. Genus Bradypus, Lin. &c. Furnished with tusks and grinders; anterior members longer than the posterior; toes united to the claws; the latter very long, compressed, bent, and sharp pointed; body covered with hair.

1. *B. didactylus*, Lin. *Two-toed sloth.* Two toes on the fore feet. * 2. *B. tridactylus*, Lin. *Three-toed sloth.* All the feet furnished with three toes.

* *B. tridactylus*, (Plate CCCLVI. Fig. 30.) The body is grey, and very hairy; the face naked; the throat yellow; and the tail somewhat ovate. A remarkable character in the full grown animal is, a wide patch or space on the upper part of the back, of a bright ferruginous, or rather of a pale orange colour, spotted on each side with black, and marked down the middle with a very conspicuous black stripe, wide at its origin, gradually tapering towards the extremity, and terminating in a sort of trifid figuring. The general aspect of the animal is extremely uncouth, the body being of a thick shape, closely covered with coarse hair; the head small; the face short, with a roundish or blunt snout; the eyes small and black; the ears flat and rounded, lying close to the head, and somewhat resembling those of monkeys. This species is about the size of a small dog, and, notwithstanding its peaceful habits, appears to be always foaming at the mouth. It creeps with its belly on the ground, and can seldom travel above fifty or sixty paces in a day. Sonnini, who has watched its movements, is not disposed to make any very considerable abatement from the accounts which former writers have given of its very sluggish march; a peculiarity which he ascribes not to volition, or moral character, but to the result of organization. To the same source he refers its extreme sobriety, and the protracted abstinence which it is capable of enduring. Cuvier has discovered that it has nine cervical vertebræ; a circumstance which forms an exception to the general rule instituted by Daubenton, namely, that viviparous quadrupeds have neither more nor fewer than seven.

As the sloth lives on the leaves and fruits of trees, it seldom quits one till it can derive no more sustenance from it, and it usually consumes two days in climbing, and as many in descending. With the latter, however, it frequently dispenses, rolling itself up, and suffering itself to fall to the ground, its tough skin and coarse hair sufficiently securing it from any unpleasant accident. So very strong are the prehensile powers of its feet, that it will sooner die of hunger than relinquish its hold. But it is also tenacious of the vital principle to a very uncommon degree, as has been ascertained by some very cruel experiments. Combining this tardy extinction of life with the animal's slow-paced motion, we may infer that the sloth approaches in constitution to some of the amphibious and reptile tribes, the sluggish circulation of whose blood seems to be connected with a proportioned retention of vitality, and probably with greater insensibility to pain. The more delicate and refined modifications of organic matter more readily wear out, and are deranged; and thus nature, amidst her countless varieties, may compensate apparent inequalities and defects in the conditions of her animated offspring.

Another trait in the history of the sloth, is its plaintive cry, or wailing repetition of *ai*, from which Buffon, following the example of the natives of Brazil, has denominated the species. This plaintive sound is most frequently uttered during the night, ascending and descending in perfect time through the hexachord; so that when the Spaniards first heard it, they fancied that the natives had been instructed in European music. It is alleged, that this despised animal is capable of shedding tears, and of exciting the commiseration even of its enemies by its piteous looks; but allowance, we presume, should be made for the warm imagination of some observers, for the carelessness of others, and for that love of the marvellous which more or less tinctures the recitals of all. That the sloth dreads rain, as has been often asserted, we cannot very easily believe, because it inhabits countries in which it sometimes rains for six or eight months continuously, and it possesses no other means of shelter than its own thick and dry covering, over which the water probably passes without penetrating to the skin. The female usually brings only one at a time, already covered with hair, and which she is said to drag slowly along on her back.

The Count de Buffon, in an animated strain of idle declamation, deplores the slow-crawling pace of the sloths, the languor of their eyes, their imperfect conformation, and their helpless condition. But the very insinuation, that nature creates animals for partaking of pure misery, is unworthy of an enlightened mind, and borders on impiety; and unless he had been endowed with the constitution and dispositions of the creature which he affects to commiserate, he was incompetent to decide that the sum of its pains exceeds that of its pleasures. This eloquent writer is, however, strangely inconsistent with himself; for, according to his view of things, animals may be called into existence, for the purpose of enduring unmixed suffering; and he brings, in support of his position, the example of man, whom he represents as a being devoted to wretchedness from the moment of his birth. After this bold and alarming preamble, we might reasonably expect much doleful wailing over the beasts of the field, the fishes of the sea, and the fowls of heaven. In the course of a few sentences, however, the sloth figures as a *solitary* instance of the cruelty of nature to her offspring; and, almost in the same breath, we are dismissed with the consoling doctrine, that these fancied miseries may not be real, and that nature, even in her most neglected productions, is more a mother than a step-dame.

Under the present family, according to Cuvier, should be ranged the new genus *Megatherium*, instituted by that celebrated anatomist in consequence of his examination of a fossil skeleton discovered in Paraguay, at a hundred feet beneath the surface of a sandy soil, near the river Plata. That this and other large quadrupeds, vaguely denominated *mammoths*, and the fragments of whose remains occur in various regions of the earth, have still their living prototypes in some of the hitherto unexplored recesses of the world, it would be rash absolutely to deny. At the supposition, however, that their races have perished, we cannot conceive why the piety of the rational inquirer should be startled or alarmed, since the Great Being, who imparts to matter organization and life, may surely recall these qualities at his pleasure; and, for reasons unknown to us, may permit certain forms of existence to endure only for a season, may lock up generations in the forsaken chambers of former oceans, and renovate or annihilate the orbs of heaven,—

> " Who sees, with equal eye, as God of all,
> A hero perish, or a sparrow fall;
> Atoms or systems into ruin hurl'd,
> And now a bubble burst, and now a world.

II. UNGULATED, or HOOFED.

Extremity of each toe entirely included in a very thick and strong horny claw, or hoof.

ORDER VII. PACHYDERMATA.

More than two toes and two hoofs on each foot; the stomach divided into lobes, which resemble one another in their parietes, and which are not adapted to rumination; intestines very long; cæcum of considerable capacity; skin very thick, and frequently naked and wrinkled; no clavicles.

1. Genus ELEPHAS, Lin. &c. Two upper cutting teeth, or tusks, cylindrical, very long, very thick, and curved; no inferior cutting teeth in the adult individual; a single grinder on each side in both jaws, composed of transverse plates, or laminæ, which are distinct and separate in early age; the appropriate bones of the nose very short, and little elevated; nostrils prolonged into a cylindrical trunk, which is fleshy, moveable in every direction, and terminated by a finger-like process, maxillary processes very extended, and exhibiting the appearance of great capacity in the skull; skin wrinkled and hairless; two pectoral mammæ; ears broad and hanging; tail of moderate length; five hoofs on each foot. Supposed to be actually existing only in the hot countries of the old continents.

1. *E. capensis*, Cuv. *E. maximus*, Lin. *Cape* or *African Elephant*. Front convex, sloping, and flattened behind; grinding teeth with crowns, or rhomboidal crusts. 2. *E. Indicus*, Cuv. *E. maximus*, Lin. *Indian* or *Asiatic Elephant*. Crown of the grinding teeth composed of transverse and parallel bands; ears broader than in the preceding. M. Cuvier has likewise ascertained, in a fossil state, the relics of *E. mammonteus*, or *mammoth*, properly so called, and of *E. Americanus*, or *animal of the Ohio*.

For more ample details relative to this interesting genus, see ELEPHANT.

2. Genus TAPIRUS, Lin. and Cuv. Forty-two teeth in all, namely, six incisors in each jaw, of which the four intermediate, both in the upper and under jaw, are wedge-shaped; the two upper lateral ones are pointed and conical, and often longer than the tusks; the corresponding ones in the lower jaw are wedge-shaped, but smaller by one half; two short tusks, like those of the carnivorous animals, in each jaw; fourteen grinders in the upper, and twelve in the lower, with crowns formed in youth and middle age by two great transverse and sharp ridges, and presenting, when worn at first, two elliptical plain surfaces, which afterwards run together into a figure nearly square; peculiar bones of the snout very short, and raised like a pent-house, affording attachments to the muscles of a very short and moveable trunk; four toes on the fore feet, only three on the hind, and all armed with hoofs; tail very short Resident only in South America.

* 1. *T. Americanus*, Lin. and Cuv. *American*, or *long nosed tapir*. (Plate CCCLVI. Fig. 31.) The specific characters are identical with those of the genus; but two fossil species have been recognised by Cuvier. The living sort has been, by different writers, very improperly denominated *sea horse*, *wild mule*, *ass cow*, *wild cow*, &c. It is usually about six feet long, three feet and a half high, and is the largest quadruped of South America. Its general appearance is that of an overgrown hog, whose round and massy form conceals the articulations of the limbs. The whole body is of a dark brown colour. The hairs on the back are so short, close, and delicate, that their presence is best ascertained by feeling; and there are very few on the flanks and under parts. The mane consists of blackish hairs an inch and a half in length, which are stiff like bristles, and gradually diminish in length as they approach the extremity, running three inches on the forehead, and seven on the neck. The proboscis, which is a prolongation of the upper lip, is extremely wrinkled at the sides, and resembles on a small scale the same organ in the elephant, but is not of the same tubular structure. The tail scarcely deserves the name, being only a thick stump about the length of the little finger, and flesh-coloured beneath. The female is distinguished by her coat, being a mixture of fawn and white, by the want of the mane, and by her larger size, being five inches longer than the male.

M. Bajon, a surgeon at Cayenne, who presented a memoir on this quadruped to the Parisian Academy of Sciences, mistaking the strangulations of the stomach for separate divisions, erroneously asserted that the tapir is a ruminating animal. Some naturalists again represent it as amphibious; but though it willingly frequents marshy situations, and is fond of bathing in lakes and rivers, it invariably fixes its haunt in elevated or dry situations, where it passes, in slumber or repose, the greater part of the day; and it seldom commences its excursions till the approach of night. Notwithstanding its lumpish bulk, it swims very well, and, if pursued or wounded, it instantly betakes itself to the water. Its ordinary pace is a pretty quick trot; but if urged, it has recourse to an awkward gallop. Its cry is a sharp hiss, and very different from what might be expected from a creature of such ample dimensions. Its sense both of sight and hearing, is uncommonly acute. It drinks like the hog, and subsists chiefly on wild fruits, and the tender shoots of trees and vegetables; and sometimes it has recourse to an argillaceous earth, impregnated with salt; but, in a domestic state, hardly any thing comes amiss to it. Although strong and muscular, it is by no means mischievous, but rather of a gentle and timid disposition, never venturing to attack man, nor even to defend itself against him; but it shews less forbearance to dogs, whose persecutions irritate and provoke it to a stubborn, and even murderous defence; for it will seize on them with its teeth, and shake them to pieces, or trample them under its feet; nay, it has been known to lay hold on the jaguar, and bruise him to death, by dragging him through the thickest parts of the forest. Except during the pairing season, the males live apart from the females; and, when two contend for the same mate, they fight desperately, and inflict mutual and cruel wounds. The term of gestation is supposed to be ten or eleven months; and the mother tends and nurses her young one with the greatest assiduity.

This species, in its wild state, generally leads a solitary life in the recesses of the woods; but, when taken young, it is very easily tamed, delights in caresses, and recognizes its master; so that, under proper management, it might perhaps be converted into a very serviceable beast of burden. Its flesh, though compared by Captain Stedman to the best beef, is generally allowed to be coarse, dry, and unsavoury; but the hide, which is very strong, thick, and compact, may be manufactured into very valuable leather. As the tapir is extremely impatient of the confinement and discomforts of a sea voyage, it is seldom seen in Europe.

3. Genus **Palæotherium**. A new genus instituted by Cuvier, in order to comprehend three or four species of which the remains have been discovered, in a fossil state, in the plaster quarries near Paris.

4. Genus **Rhinoceros**, Lin. &c. No tusks; grinders with a flat crown; sometimes teeth placed in the front of the jaws, which may be compared to the cutting-teeth in other mammiferous animals; the peculiar bones of the snout elevated and supported; one or two thick horns, which appear as if composed of agglutinated and compact hairs; neither trunk nor snout-cartilage; fleshy and moveable lips; hide thick and hairless; legs short; feet with three toes, and three large hoofs; tail short.

1. * *R. unicornis*, Lin. &c. *Single horned Rhinoceros.* (Plate CCCLVI. Fig. 32.) With one horn. 2. *R. bicornis*, Lin. &c. *Double-horned Rhinoceros.* With two horns. A species seems also to have existed in Siberia with two horns, and the head much elongated.

* *R. unicornis.* The animal which is so aptly denoted by this appellation, measures at least twelve feet from the extremity of the snout to the origin of the tail; nearly as much in circumference, and from six to seven feet in height; thus approaching to the elephant in respect of bulk and mass, though apparently much smaller, from the circumstance of its limbs being comparatively much shorter. Its only distinct organ of touch, is the upper lip, which is very flexible, advancing over the lower, and capable of great extension. Its horn, which is brownish, very hard, and solid throughout, and which sometimes measures three feet in length, and eighteen inches in circumference at the base, defends all the anterior parts of the mouth and face; so that a tiger will more readily attack the elephant, whose trunk it can seize, than the rhinoceros, which it cannot face, without danger of having its bowels torn out. With its horn the rhinoceros also grubs up roots, and tears the brush-wood on which it feeds. Its skin, which is of a blackish, or deep-brown hue, is very tough, thick, naked, wrinkled like the bark of an oak, covered with large, callous tubercles, or granulations, and disposed about the neck into large plaits or folds; but between these, and under the belly, it is soft, and of a light rose colour. We must here remark, however, that it is by no means so insensible or impenetrable as has been commonly supposed. Buffon, in one passage, positively asserts, though without quoting his authority, that it is not to be pierced by any arms of the hunter; a little further on, he cites, with much approbation, the account of this animal by Mours, which, nevertheless, contradicts his prior statement; and, in the course of a few pages more, he turns to the inefficacy of darts and lances; nay, he will not allow a single particle of sensibility, though Dr. Parsons, to whom he also refers, had frequently seen the creature tickled with a wisp of straw; and we learn, from various descriptions, that it is so much harassed by insects, that it wallows in the mud to get rid of them. The head is longer, in proportion, than that of the elephant; the ears are moderately large; the eyes are very small, and so situated that the animal can only see objects which are nearly in a direct line before it; the back, instead of rising, as in the elephant, exhibits a considerable depression; the belly is somewhat pendulous, like that of the hog; and the legs are very short, thick, and strong, the tail is short and slender, flattened at the extremity, and covered on the sides with a tuft of thick and hard bristly hairs. The roughness of the tongue seems to have been a matter of dispute among naturalists; for some assert that, with the asperities of this organ, the animal can lick off the flesh from a man's bones; whilst others maintain that it is quite soft, like that of a calf. Both statements are partly true, and partly exaggerated; in the young rhinoceros, the tongue is soft, presenting no prickles, nor any discernible rudiments of spines; whereas, in the full-grown individual, it is very rough. The intestines are very capacious, and formed like those of the horse; while the stomach has a greater resemblance to that of the hog. Though equal in weight to twenty-five or thirty men, the portion of brain in the rhinoceros is but one-third of that which usually belongs to an individual of the human species.

The one-horned rhinoceros is a native of several parts of India, and also occurs in Abyssinia, Ethiopia, and various districts of Africa. Its food is wholly vegetable; and it is particularly fond of the *stæbe rhinocerolis*, the fetid stapelia, rice, the sugar-cane, and a great many rough and spinous plants. The consumption and havoc which it occasions in cultivated fields, are prodigious, and, at the same time, unredeemed by its services, or the trifling value of its carcass. Though not ferocious, it is very untractable, and occasionally liable to paroxysms of rage. The female usually brings forth only one at a time; and her period of gestation is about nine months. The rudiments of the horn are discernible in the fœtus; but this defensive weapon shoots up very gradually, and is only an inch long at the end of two years. During the first month, the young rhinoceros is about the size of a large dog; and it is only half-grown in two years; so that the natural term of its life may nearly correspond with that of man. Notwithstanding the shortness of its limbs, this quadruped is capable of running with great swiftness; and, from his strength and thick covering, of rushing, with resistless force, through woods, the smaller trees bending, like twigs, in his path. As a compensation for imperfect vision, he has an acute and very attentive ear, and will listen, with surprising steadiness, to any kind of noise. His sense of smell, likewise, is very delicate; and the Hottentots, warned by experience, are careful, even when at a considerable distance, not to get to the windward of him, as he seldom fails to follow the scent directly, and attack the object of his pursuit.

The flesh of the rhinoceros is much relished by the natives of India and Africa; the under part of the foot being reckoned the most delicate portion; the rest tasting like tough pork, and smelling of musk. Medical and superstitious charms have been foolishly ascribed to the horn and other parts of the animal, and which, like the tractors, or animal magnetism, may sometimes produce salutary effects on the credulous, through the intervention of the imagination.

5. Genus Hyrax, Lin. &c. Two upper, bent, and pointed cutting-teeth; four lower, projecting forward; four broad and tuberculated grinders on each side of each jaw; small upper tusks in the young animal; body thick, covered with hair; neither trunk nor horns; four toes on the fore feet; only three on the hind, all armed with, and included in horny claws, of which the intermediate one in the hind feet is sharp and oblique; the tail wanting.

1. *H. Capensis*, Lin. *Cape hyrax*, *Cape askoko*, or *Cape cavy*. Grey-brown above; paler beneath. This species is now ascertained to be the same with *H. syriacus*, or the *Syrian askoko*, so well described by Bruce. But that celebrated traveller is supposed to have been mistaken, when he ascribes to this quadruped the faculty of chewing the cud.

6. Genus Hippopotamus, Lin. &c. Head broad; muzzle much inflated; lips very thick; four very large, pointed, and projecting cutting-teeth in the lower jaw; four, bent on the under side, in the upper; tusks very strong, especially the lower, which are curved; twelve grinders in each jaw; skin thick; legs very short; four toes on the feet, invested with small hoofs; tail short. A small fossil species has been detected by Cuvier; but the only living kind at present known is—

* *H. amphibius*, Lin. &c. *Amphibious hippopotamus*, or *river horse*. (Plate CCCLVII. Fig. 33.) It seems to be generally admitted that this is the *behemoth* which is described in terms of eastern sublimity, in the book of Job; nor can it be denied that, after making the requisite abatement on the score of oriental amplification, most of the circumstances will apply to the hippopotamus; yet the insignificant tail of the latter will scarcely justify the lofty expression, *he moveth his tail like a cedar;* and it is, perhaps, no extravagant conjecture to suppose, that *behemoth* alluded to one of those enormous herbivorous quadrupeds, of which only the relics are now found imbedded in the earth.

Le Vaillant reports, that one of this species, which he killed, measured, from the tip of the nose to the insertion of the tail, ten feet seven inches; and, in circumference, eight feet eleven inches; but, from the smallness of its tusks, he supposed it to be a young one. Mr. Bruce mentions some in the lake Tzana, as exceeding twenty feet in length: but, in general, the dimensions of the hippopotamus may be pretty fairly assimilated to those of the rhinoceros, the form of the whole animal exhibiting a most uncouth and unweildy appearance; the body being extremely large, fat, and round; the lips very thick and broad, and scattered with tufts of strong, short bristles; the eyes and ears small; and the feet very large. The whole animal is covered with short hair, which is much more thinly set on the under than on the upper parts. When just emerged from the water, this huge beast appears of a palish-brown, or mouse colour, with a bluish or slate coloured tinge on the upper parts, while the skin of the belly, which appears through the hair, is flesh-coloured; but, when perfectly dry, the general colour is a dull, obscure brown. The skin is excessively tough and strong, except on the belly, where it is softer. The hippopotamus has only one stomach, though it is composed of different cells, or divisions analogous to those observed in the camel.

The animals of this species inhabit the larger and shady rivers of Africa, from the Niger to the Berg, near the Cape of Good Hope; but they are now much thinned; nor are they found in any of the African rivers that run into the Mediterranean, except the Nile, and in that portion of it only which traverses upper Egypt; and they occur in the fens and lakes of Ethiopia. From the unweildiness of their frame, and the shortness of their limbs, they are timid and sluggish on land; and, when pursued, they betake themselves to the water, plunge in, and walk at the bottom, quite at their ease, though often constrained to rise to the surface, for the sake of breathing. In the day-time, they are so much afraid of being discovered, that, when they take in fresh air, they put their nostrils out of the water; but in rivers, that are unfrequented by mankind, they are less cautious, and put out the whole head. If wounded in the water, they will rise, and attack boats or canoes with great fury, or even sink them, by tearing large pieces out of their sides. In shallow rivers, they make deep holes in the bottom, to conceal their bulk. When they quit the water, they usually put out half their body at once, and smell, and look around; but sometimes they rush out with great impetuosity, and trample down every thing in their way. During the night, they leave the rivers, in order to feed on sugar canes, rushes, millet, rice, &c.—consuming great quantities, and occasioning much injury to the cultivated fields. They are naturally of a harmless disposition, and even capable of being tamed; but it is dangerous to encounter them out of the water, especially in the pairing season, when one of them has been known to pursue a Hottentot for several hours; and, from the extreme width of the gap, one of them is capable of cutting a man asunder in an instant. The males, also, fight furiously on shore for their mates. The female goes with young about nine months, and brings only one at a time, giving it suck both on the land and in the water, and sometimes carrying it on her back. The milk resembles that of the cow, but is much more thin and watery. A full-grown individual of this species will weigh five or six thousand pounds, from one to two thousand of which are usually fat, or lard, which is reckoned particularly delicious, as are the feet and tail, when roasted. The dried tongue is also regarded as a treat for an epicure. The negroes of Western Africa still consider the hippopotamus as a local deity, though they have no objection to a slice of him when dead. The tusks are much used by modern dentists in making artificial teeth, being not only harder than common ivory, but not so apt to become yellow. The skin is cut into thongs for whips, which, for softness and pliability, are preferred by the Africans to those which are made of the hide of the rhinoceros.

7. Genus Sus, Lin. &c. Cutting-teeth varying in number from two to six; tusks very long, and often projecting beyond the mouth; grinders with tuberculated crowns; snout moveable, and terminated by a particular bone; four toes, fenced with hoofs, on each foot, and of which only the two intermediate touch the ground; body covered with bristles; tail of moderate length. Resident in both continents.

This family of animals includes but few species; and they are distinguished by an appearance and manner that are far from equivocal. Their general aspect is heavy and sluggish; and they consume a large portion of their time in eating and sleeping. Though partial to vegetable food, they reject hardly any thing that is digestible. They grub up roots with their snout; delight to wallow in the mire; and are very prolific.

1. * *S. scrofa*, Lin. &c. *Common hog.* Body bristled in front; tail hairy. 2. *S. Africanus*, Lin. &c. *Cape hog.* Two front teeth in the upper jaw. 3. *S. Æthiopicus*, Lin. *Ethiopian hog.* Wattles beneath the eyes. 4. *S. babiroussa*, Lin. *Babiroussa*, or *horned hog.* The two upper tusks growing from the lower part of the front. 5. *S. tajassu*, Lin. *Pecari*, or *Mexican hog.* Tailless, with a glandular orifice on the back. 6. *S. patira*, Desmar. *Patira.* A white band of an inch in breadth, passing from the withers to both sides of the neck.

* *S. Scrofa.* There can be no doubt that the wild boar, and the common domestic hog, are specifically the same; for, not only are they capable of breeding together, but, in consequence of an interchange of conditions, the appearance and habits of the races are exactly reversed. The wild boar is usually smaller than the domesticated, and of a dark brindled grey colour, or sometimes blackish; but, when only a year or two old, it is of a pale, tawny, or dull, yellowish brown; and, when quite young, it is marked by alternate dusky and pale stripes, disposed longitudinally on each side of the body. Between the bristles there is a finer and somewhat woolly hair. The snout is rather longer, in proportion, than that of the tame hog; but the principal difference consists in the superior size and length of the tusks, which are often several inches long, and capable of inflicting the most severe and fatal wounds. As the animal, however, advances in age, he becomes less formidable, because his tusks bend upwards, or make so large a flexure, as often rather to impede than assist his hostile purposes.

This useful quadruped is a native of almost all the temperate parts of Europe and Asia, and is also found in the upper regions of Africa, but is a stranger to the arctic latitudes. In consequence of domestication, it now presents us with a great variety of breeds. Of these, one of the most striking is characterized by solid or undivided hoofs. Specimens of this description appear to have been occasionally met with in Pæonia and Illyria, in the days of Aristotle; if we may implicitly rely on Gesner, they have also occurred in England and Flanders; and Linné assures us, that they are common in Sweden, especially in the neighbourhood of Upsala. The large-eared variety is very common in France, Germany, and England. In some parts of Italy, the inhabitants cherish a peculiar breed, which, instead of bristles, have very short and fine hair, that gives them a naked appearance; they have likewise remarkably short legs, and are capable of being fattened to a great size. The Polish and Russian hogs are rufous, or yellow, and seldom attain to any considerable bulk, whereas those of Bosnia and Servia, which are fattened for the Vienna market, have a less repulsive appearance than the common breeds, and are distinguished by a soft, frizzled, or woolly hair between the bristles. The *horned hog* of Johnston is probably a mere chimera, as his figure appears to be only a bad representation of the *babiroussa.* The Chinese, who are very fond of pork, rear immense herds of the Siamese breed, which is smaller than the common sort, has the legs and tail shorter in proportion, the back nearly hairless; the belly very large and pendulous; and the prevailing colour black, faintly dashed with white. It is, moreover, a very cleanly animal; and its flesh is both more white and more delicate than that of most of the race. The same, or a similar variety, occurs in the South Sea Islands, where, with the dog, it is honoured with domestic treatment. The variety called the *Guinea hog*, which Linné, and some of his followers seem, improperly, to have considered as a distinct species, has a smaller head than the common, with long, slender, sharp-pointed ears, and naked tail, reaching to the ground. Its colour is rufous, and its hair softer, shorter, and finer than in other kinds. Into this country there has been lately introduced another breed, which is expected to rival or surpass all the rest: the females are extremely prolific; and the colour of the pigs is, in general, most fancifully diversified, some being striped, longitudinally, with brown and black, others with brown and blue, and others with black and white. The stock resulted from a wild boar brought from America, and a sow of the improved Chinese breed.

The structure of the hog is, obviously, adapted to its mode of life; for Nature, which has destined it to grub in the earth for food, has given it prone propensities; a strong brawny neck; small eyes, seated high in the head; a long snout; a callous and tough nose; and a quick sense of smell. Its apparent gluttony and voracity proceed from the unusual capacity of its stomach and intestines, and, whilst its coarse and groveling sensuality may repel the human spectator, they are subservient to other purposes than the mere gratification of animal craving, contributing not only to remove nuisances, but to convert the most nauseous refuse into wholesome nutriment. We are apt, however, to conceive it to be much more sordid and indelicate than it really is; for it selects the plants on which it feeds with equal sagacity and niceness, rejecting more species than most of the phytophagous quadrupeds; is never poisoned, like some other animals, by mistaking noxious for wholesome aliment, and prefers the luxurious truffle to all other vegetable productions. Among the grasses, it manifests a predilection to the most succulent; and, among the roots, to the most nourishing. As its ordinary lot is to feed, and to be fattened for the market, its *intellectual powers*, if we may be allowed the expression, are very generally neglected: yet it may be trained to various feats and habits, which bespeak both sagacity and talent; and *learned pigs* have been more than once exhibited in most of the considerable towns of Europe. Independently, too, of all tuition, it has been frequently observed to collect straw with its mouth, in order to form a warm bed, when the wind blows keenly, and to call its companions by repeated cries, to assist in the work. Its extreme sensibility to wind, which has, probably, given rise to the popular expression, that it *sees* it, denotes, at all events, a more delicate organization than we are disposed to ascribe to it; and, though it generally, passes for very dirty, yet, when it is allowed free and suitable accommodation it studiously keeps its hovel and sleeping place clear of filth. A new-born pig instinctively deposits its dung in a corner, apart from the spot on which it lies; and this attention to cleanliness grows with age, insomuch, that if kept dirty, they become restless and discontented, and never thrive. Their reputation for nastiness has, perhaps, originated in the circumstance of their being addicted to roll in the mud, or in newly stirred soil; but this propensity, which is by no means peculiar to them, only betrays their eagerness to remove the itching sensation produced by insects. The same uneasy feelings appear to be induced before rain, when these creatures, as well as poultry, rub themselves in the dust. Let us also recollect, that few animals, when compelled to exert themselves, evince more determined courage, or more lively sympathy with those of their own species; for the moment that one of them utters a signal of distress, all within hearing will run to its assistance. That the sow sometimes devours her new-born offspring, cannot be denied; but it is a rare occurrence, and has, doubtless, its origin in some other cause than mere greed or hunger, because, though ill-fed, or even starving, she generally betrays the most tender concern for her young; and the anomalous phenomenon in question has been also remarked of the cow, the ewe, the bitch, and, indeed, of the females of most domestic animals. On most occasions the heroism with which a sow defends her litter is truly admirable: the slightest call on their part awakens her solicitude, violence animates her fury, and few assailants can intimidate or resist her. When the danger is over, she recalls her dispersed family; and, if she misses one of them, she searches about for it with the most interesting anxiety.

It is generally believed, that swine will live to the age of twenty or thirty years; but as it is neither profitable nor convenient to allow them to grow old, we have few instances of the utmost term of their longevity. Although they continue growing for four or five years, they are capable of breeding at the age of nine or twelve months; they only go four months with young; and they have been known to produce even twenty at a litter. From the minute and reasonable calculations of the celebrated Maréchal de Vauban, who disdained not to pen a treatise on hogs, it results, that, in the course of eleven years, the multiplied produce of a sow may amount to six millions of individuals. The great weight to which some of the Berkshire swine have been fed, would appear altogether incredible, had it not been so well attested. Thus, Mr. Young, the agriculturist, mentions one which weighed upwards of eighty-one stone. Another, killed at Congleton, in Cheshire, in 1774, measured, from the nose to the end of the tail, three yards eight inches; and, in height, four feet and a half: its weight, when alive, was 1410 lb. and, when killed and dressed, 1215 lb.

The skins of this species, when properly prepared, are in great request by saddlers, book-binders, and other artisans. The blood, feet, tongue, and lard, are all used as food; and the lard chirurgically, being an ingredient in various sorts of plasters, and very successfully employed by some bone-setters, in cases of sprains and fractures. The bristles are made into brushes of various descriptions, and are also employed by shoemakers, instead of needles: while the adventurous rock-men in Orkney twist them into ropes, with which they let one another over the steepest and highest cliffs, in quest of wild fowl and their eggs. Linné observes, that pork is a wholesome food for athletic constitutions, or for those who use much exercise, but that it is unfriendly to people of sedentary habits of life. In a naval and commercial country, like our own, it is justly considered as an article of primary importance; for it takes salt better than any other kind of flesh, and is, consequently, capable of being longer preserved. The Jews and Mahometans, influenced by mistaken notions of religion, abstain from it as a food, and consider themselves, in some measure, defiled even by touching it. The inhabitants of China, on the contrary, are so addicted to it, that multitudes, it is alleged, from this partiality alone, have been deterred from adopting the institutions of Mahomet. In ancient Rome, the domestic hog was held in singular esteem: and the art of rearing and fattening pigs was formerly discussed by their economical writers, under the title of *porculatio*. Under the Emperors, when the luxury of the table, and the refinements of cookery had reached to a most extravagant pitch, the ministers of epicurism exercised their ingenious cruelty on this and other tribes of animals, in a manner which makes humanity shudder, and over which, as well as over some of the modern aping of these savage culinary processes, every regard to the better feelings of our nature requires that we draw a veil.

Under the present order, Cuvier has included another genus, which he has denominated *Anoplotherium*, comprising three or four species, of which the fossil remains have been observed in the plaster quarries of Montmartre.

Order VIII. RUMINANTIA, PECORA, Lin.

Two toes and two hoofs on each foot; for the most part no upper cutting teeth; grinders with a flat crown; four distinct stomachs; articulations of the jaw loose, and admitting a lateral motion; upper lip more or less cleft; horns, or antlers, sometimes in both sexes, and sometimes only in the males; no clavicles; teats inguinal; endowed with the genuine faculty of rumination.

Section I.

Neither horns nor antlers, but the three kinds of teeth.

1. Genus Camelus, Lin. &c. Two cutting, and several canine teeth, in the upper jaw; six cutting and two canine, in the lower; upper lip much cleft; an appendage to the fourth stomach for containing water; one or two hunches on the back; callosities on the knees and breast; two very small hoofs; and a thick sole on each foot; neck very long and arched; ears and hair short. Resident in the warm and eastern countries of the old continent.

* 1. *C. Bactrianus*, Lin. *Bactrian camel*, or *camel*. With two hunches on the back. * 2. *C. dromedarius*, Lin. *Arabian camel*, or *dromedary*. With one bunch on the back.

* *C. Bactrianus*. See Camel.

* *C. dromedarius*. (Plate CCCLVII. Fig. 34.) Of this Arabian species there is a variety smaller than the ordinary sort, and which, as more capable of being trained to the course, was termed by the ancient Greeks, *καμηλος δρομας*, or *race camel*, which the Romans translated by *dromedarius*, a term which the moderns have applied to the Arabian species in general.

The ordinary height of the dromedary, measured from the top of the bunch to the ground, is about six feet and a half; but from the top of the head, when the animal raises it, not much less than nine feet. The head is small; and, by the flexure of the long neck, usually kept on a level with or even under the top of the bunch, the body is of a long and meagre shape; and the tail, which is slighly tufted at the end, reaches to the joints of the hind legs; the limbs are somewhat slender; the feet very large, hoofed in a peculiar style, and having their under part covered with an extremely strong, tough, and pliable skin, which, by yielding in all directions, enables the animal to travel, with singular ease and security, over dry, stony, and sandy regions. The general colour of the Arabian camel is an uniform dusky brown, more or less tinged with ferruginous; the hair is particularly fine and soft, and the whole appearance singularly grotesque; and, according to our notions, indicative of deformity. It is found in the warmer parts of Asia, and in the upper regions of Africa. In Asia it is said not to occur further north than Persia, and, in Africa, not further south than Ethiopia.

The Count de Buffon has laboured to support a favourite notion, that the large dorsal bunch of the camel originated in harsh treatment, and has, in the course of many generations, become a permanent character of the race. This hypothesis is not only gratuitous, but seems liable to insuperable objections. We may ask, for example, how comes it to pass that nothing analogous is observable among other species of quadrupeds, which have long experienced the oppression of unfeeling masters? and why is the Arabian camel uniformly produced with one, and the Bactrian as uniformly with two bunches? It is impossible, however, not to admire the Count's eloquent recital of the manner in which this animal performs its journies, and of the important services which it renders to its owner. The Arabs emphatically call the dromedary the *ship of the desart*; and the expression seems not to be misapplied, when we consider that it is the only quadruped capable of conveying their merchandize across the burning and barren sands. When the traveller is not in haste, or when he accompanies a caravan, the progress of which is always slow, he may sit tolerably at his ease, and even sleep in a sort of covered litter of wicker-work, fixed on the dromedary. In this manner the women and children of the Arabs are conveyed, when they migrate in families. The drivers of the loaded dromedaries have each a stick, which they use sparingly, when occasion requires; and those who ride have recourse to a long leathern strap as a whip, making use, at the same time, of a clicking of the tongue.

Though dromedaries are, in general, intelligent, and extremely tractable, yet, in the rutting season, they are subject to fits of rage, in one of which they have been known to take up a man in their teeth, throw him on the ground, and trample him under their feet. The Arabs also assert that these creatures are very sensible of ill treatment, and that they will retain the recollection of an injury, till an opportunity offers of gratifying their revenge. Eager, however, as they are to express their feelings of resentment, they have no sooner done so than they cease to harbour any rancorrous emotions. Hence, when an Arab has incurred the displeasure of his dromedary, he throws down his garments in some place near which the animal is to pass, and disposes them in such a manner that they appear as if they covered a sleeping man. The dromedary recognizes the clothes, seizes them in his teeth, shakes them with violence, and tramples them in a rage, till his anger is appeased, when he leaves them, and then the owner of the clothes may make his appearance without any fear, and load and guide his beast as he pleases. "I have sometimes seen them," says Sonnini, "weary of the impatience of their riders, stop short, turn round their long necks to bite them, and utter cries of rage. In these circumstances, the man must be careful not to alight, as he would infallibly be torn to pieces: he must also refrain from striking the creature, as that would but increase his fury. Nothing can be done but to have patience, and soothe the animal, by patting him with the hand, (which frequently requires some time,) when he will resume his way and his pace of himself.

The breeding season of the dromedary commences in spring, the term of gestation is twelve months, and the female bears only one at a time. The new-born young measures only two feet in height, but grows so rapidly in the early stage of its existence, that, in the course of eight days, it measures nearly an additional foot: it sucks during twelve months, and attains not to its full growth till six or seven years. Its life is usually limited to forty or fifty years. In April, and the early part of summer, it is subject to a gradual moulting, somewhat analogous to that of the horse. Its ordinary quantity of daily food may be estimated at 20 lb. of hay.

In opposition to the opinion of Buffon, we may refer to the testimony of Du Halde, the relations of several merchants who have travelled in Bucharia, in the north of India, and on the confines of China, and to the weighty name of Pallas, in favour of the existence of dromedaries in a wild state. With respect to their fleetness, it has been repeatedly affirmed, that they can travel at the rate of fifty leagues a-day: but this, we have reason to believe, is a vague exaggeration: much, at the same time, will depend on previous education, and on the mode of travelling; for those which are regularly bred to the course, are much more nimble than those trained to burthen; and a single dromedary will often traverse a given portion of space in a much shorter period than is compatible with the regulated movements of a caravan. Much, in like manner, has been said of the marked antipathy which subsists between horses and camels; and, because ancient and modern writers have maintained the fact, while both species associate very cordially in the caravans of the Arabs, the fact itself has latterly been treated as fabulous. It deserves, however, to be remarked, that here, as in similar cases, the effect of habit is too much overlooked. A horse which had never seen a camel would, we doubt not, startle when he first encountered an animal of such an unusual appearance; the writer of this article, indeed, has seen very spirited horses betray evident symptoms of uneasiness and alarm on approaching dromedaries in Tuscany; but, since dogs and cats can be reconciled to one another's company, we can perceive no reason why the horse and the camel should not become sufficiently familiar to journey over a sandy desart in the best humour imaginable. The horse is afraid of an ass, of a stone out of its place, or of a leaf falling to the ground, because his powers of vision are comparatively imperfect; but, when habituated to such objects, he views them with indifference.

A robust dromedary will carry as much as two mules, and is contented to feed as coarsely as the ass. Its flesh is prized as an article of food; the female yields a large quantity of wholesome milk, of which are made small cheeses that fetch a high price; the hair is much in request for painters' brushes, the manufacture of tents, carpets, shawls, &c.; the skin is converted into leather; the urine into sal-ammoniac; and even the dung into fuel.

The introduction of this race of animals into our

West India Islands was attempted some time ago, but without success; for the planters, unaccustomed to their habits and manners of feeding, are said to have mismanaged them, while the chigoes, by insinuating themselves into their soft feet, and producing inflammation, and, at length, painful ulcers, seem to have rendered them quite unfit for service. In Fortaventura and Lancerota, two of the Canary islands, and in the Duchy of Tuscany, they thrive very well, and are found to be very serviceable as beasts of draught and burthen.

2. Genus Lama, Cuv. Camelus, Lin. Four cutting teeth in the upper jaw only; canine teeth in both jaws; no hunch on the back; neck very long, but not bent; ears long; hair long and woolly. Resident in South America.

* 1. *L. pernichcatla*, *Camelus lama*, Lin. *Llama.* Pale ferruginous above; white beneath; back smooth; breast with a bunch. * 2. *L. vicugna*, *vicuna.* Purplish-brown above; whitish beneath; body smooth and woolly; snout obtuse; tail upright. 3. *L. huanaca*, *Guanaco.* Tawny above; white beneath; back gibbose.

* *L. pernichcatla.* The height of this animal is about four feet and a half; its length, from neck to tail, nearly six feet; and its usual weight about 300 lbs. In consequence of domestication, the hair, which is naturally long and coarse, becomes short and smooth.

The Llama, which inhabits the lofty mountains of Peru, Chili, and other parts of South America, is so gentle and tractable, that it is used as a beast of draught and burden. These quadrupeds proceed on their journies with great gravity, insomuch that nothing can induce them to change their pace. Like the camel, they lie down to be loaded, and when exhausted with fatigue, no blows will excite them to advance. In a fit of apparent caprice, they will sometimes lie down, when caresses alone will prevail with them to rise again; and when irritated, they will eject their saliva to a considerable distance. In conveying the rich ores from Potosi to Cozer, a distance of 200 leagues, they usually consume nearly two months. When loaded, they march in troops, and are accompanied by forty or fifty others, to relieve those which are fatigued. Their conductors encamp under tents, to allow them to pasture by the way, for they require no other feeding. Sometimes they will march four or five days successively, before they seem desirous of repose; and then they rest, spontaneously, twenty or thirty hours, before they resume their journey. At other times, when inclined to rest only a few minutes, they bend their knees, and lower their body with great caution, to prevent their load from falling off, or being deranged. In going along, during the day, they browze wherever they find herbage, and generally pass the night in sleep and in chewing the cud.

Among their native mountains, the Llamas associate in immense herds, on the highest and steepest parts, where they frequently climb rocks along which no man will dare to follow them; and when the rest of the herd are feeding, one is always stationed as a sentinel, on some prominent outpost, and whose call, which is the signal of alarm, makes them scamper away at full speed.

Bolivar affirms, that, in his time, no fewer than 300,000 Llamas were employed in the conveyance of gold and silver ore. Without the aid of these animals, indeed, the Spaniards who inhabit the mining districts of South America, would labour under serious inconvenience for the transport of their merchandize and treasures, since mountains, which would be altogether inaccessible to the horse, are with facility traversed by the Llama.

This species breeds when three years old, and begins to decay at twelve. Its flesh has been compared to mutton. The wool or hair, though it has an unpleasant smell, is manufactured by the Indians into cloth; and the skin is used both for shoes and harness.

**L. vicugna.* The vicuna bears a strong resemblance to the Llama, but is of a lighter and more delicate aspect, and of a smaller size. The head is smaller and shorter in proportion; the eyes are remarkably large and full; the ears somewhat sharper, and the limbs more slender. The hair of this animal is of a very soft, wavy, and woolly nature, about three inches long on the breast, and at the extremity of the tail; but, on the other parts, not more than one inch.

The vicuna inhabits the wildest and steepest heights of the Cordilleras, whence the severity of the climate, and perpetual snow, banish every other living being but the guanaco, which associates with it. These two species abound in the province of Cochabamba, in that branch of the Cordilleras which stretches to the interior of the mountains of the river Cotacages, and even to the gold mines of the tribe of Choquecamata, situated in the neighbourhood, where passengers often encounter them in flocks of several hundreds, and, what is remarkable, most of them males. The difficulty of breathing, induced by motion or agitation in such an elevated region of the atmosphere, and the fleetness of these animals, habituated to such a light air, render it a very arduous task to pursue them to the rugged summits of these immense ridges. But the timidity of the vicunas has suggested an easy, and by no means expensive mode of securing them. The Indians, with considerable address, collect them into a level spot, enclosed by a simple worsted thread, tied to stakes, at regular distances, and to which bits of rags are suspended, so as to wave in the wind. When once the animal gets within this mock enclosure, it is so alarmed at the motion of the rags, that it has neither the courage to approach them, nor to leap over the frail barrier, unless a guanaco happens to be among the flock; for the latter springs over without hesitation, and is followed by all the vicunas. At present multitudes of these quadrupeds are sacrificed to the increasing demand for their valuable wool, which is exported to Europe, because, according to a barbarous and improvident system of management, each fleece, which weighs about half a pound, costs the life of the creature which produces it. Hence, if some mode be not devised of confining them within extensive folds, and subjecting them to regular shearing, the race will soon be nearly exterminated.

When the vicuna is young, its flesh is reckoned good for the table; but its wool is justly held in the highest estimation, since it is convertible into stuffs as soft and fine as the shawls of Cachemere. This article, however, is seldom sent to Europe pure, being almost always mixed with wool of an inferior quality. As the animal is very gentle and caressing, when tamed, it probably might be naturalized in the Pyrenees, on the summit of which the snow scarcely ever thaws, and the pasture is particularly good.

Genus Moschus, Lin. The habit of the deer tribe, but without horns or antlers; no cutting teeth in the upper jaw, eight in the lower, two very long tusks projecting from the mouth, in the upper. Resident in the old continent.

*1. *M. moschiferus*, Lin. &c. *Musk*, or *Thibetian musk*. Follicle near the navel; tail short. 2. *M. memina*, Lin. *Memina*. Olive ash above, white beneath; the sides spotted with white, and no false hoofs. *3. *M. pygmaeus*, Lin. *Pigmy*, or *Guinea musk*. Tawny brown above, white beneath; spurious hoofs wanting. 4. *M. Javanicus*, Lin. *Java musk*. Rusty coloured above, longitudinally white beneath, with villous tail, and small appendicular hoofs. 5. *M. Indicus*, Lin. *Indian musk*. Rufous above, whitish beneath, with spurious hoofs, and the tail somewhat lengthened. 6. *M. Americanus*, Lin. *American*, or *Brazilian musk*. Tawny brown, with black muzzle, and white throat.

**M. moschiferus*. (Plate CCCLVII. Fig. 35.) The production from which this animal takes its name, was long known and valued, before any certain account of the animal itself had been obtained by naturalists. A native of the remote parts of the east, and an inhabitant of the desert, it was considered only as an object of the chace, and confounded with the different species of the deer, or antelopes, which abound in those regions. It is an elegant, fleet, and lively creature, with the hind considerably longer than the fore legs, measuring three feet three inches in length, and weighing from 25 to 30 lb. The eyes are large, with a rufous brown iris; the ears are long and large, furnished, internally, with long white hairs, blended with others of a greyish tinge, and outwardly, with hairs of a reddish black, mixed with grey. The predominant colour of the hair on the body is blackish, with fawn, or even reddish tints. The tail is so short and concealed in the fur, as to be scarcely visible. The female is smaller than the male, and not only wants the tusks, but the follicle. In the young males this last mentioned receptacle is empty; but, in the full-grown individual, it contains from one to two drachms of a soft, unctuous, brown substance, of the most powerful and penetrating smell, and which is the genuine musk.

The present species is a native of the kingdoms of Bontan and Tonquin, of the province of the Mohang Mery, in China, of Chinese Tartary, Thibet, and even of some portions of Russian Tartary, as about Lake Baikal, and the rivers Jenesei and Argun. Its favourite haunts are the tops of pine-covered mountains, where it delights to roam in places of the most difficult access, springing and bounding with great nimbleness, and when pursued, taking refuge in the highest and most rugged summits. It lives retired and solitary, except in autumn, when large flocks collect, in order to change their residence, being driven southward by the approaching cold. During this migration the peasants lie in wait for them, and either take them in snares, or kill them with bludgeons and arrows. So lightly do they bound over the snow as scarcely to leave a trace of their progress. Though timid and gentle in their wild state, they are never completely reconciled to domestication, and they pine and die in captivity. Their breeding season is in November and December, when the males sometimes maintain furious and obstinate conflicts for their mates, and when they diffuse a very strong musky odour. With their tusks they are supposed to hook up roots, and catch at the small twigs and branches of trees and shrubs on which they feed. They are particularly fond of lichens, arbutus, rhododendron, and whortle-berry plants.

The flesh of the young is esteemed a delicacy; and the skins are manufactured by the Tungusians and the Russians into bonnets and winter dresses; but the animal is chiefly hunted and destroyed for the sake of its musk. This article is procured, of the best quality, and in the greatest abundance, in Bontan, whence it is carried for sale to Patna.

**M. pygmæus*. (Plate CCCLVII. Fig. 36.) This is a beautiful and elegant little quadruped, considerably smaller than the domestic cat. The upper part of the body is bright bay. The legs are so slender as scarcely to exceed the diameter of a swan's quill. The head, ears, and eyes, are somewhat large in proportion, and the aspect is uncommonly mild. As it does not occur in Guinea, it is improperly denominated *Guinea musk*; and, by some naturalists, it has been still more absurdly named the *Greenland stag*. It is found in many parts of the East Indies, and the Indian islands, particularly Java, where the natives catch great numbers of this species in snares, and carry them to the market in cages, frequently selling them as low as 2½d. a piece; but all attempts to convey them alive into Europe have hitherto failed.

SECTION II.

Horns or antlers; no tusks in either jaw, nor cutting teeth in the upper.

SUBSECTION I. The head of the male only armed with solid and deciduous antlers; no cutting teeth in the upper jaw.

4. Genus CERVUS, Lin. &c. No cutting teeth in the upper jaw; eight in the lower; a lachrymal vessel before and under each eye; no gall bladder; hair smooth; tail short. Resident in both continents.

*1. *C. elaphus*, Lin. *Stag*, *hart*, or *red deer*, (for the male, *hind* for the female.) Rufous brown; horns branched, round, and recurved. *2. *C. capreolus*, Lin. *Roe*, or *Common roe*. Body brown-tawny; horns branched, round, erect, with bifid summits. *3. *C. tarandus*, Lin. *Rein-deer*. Horns branched, recurved, compressed; extremities palmated. *4. *C. alces*. Lin. *Elk*, *moose*, or *moose deer*. Horns stemless and palmated; throat carunculated. 5. *C. coronatus*, Geoff *Crowned stag*. Horns like those of the elk, but much smaller, and the palmations much larger, and more indented in proportion. *6. *C. dama*, Lin. *Fallow-deer*, *Common buck and doe*. Horns branched, recurved, compressed, and palmated at the top. 7. *C. muntjac*. Lin. *Rib-faced deer*. Horns rising from a cylindrical hairy base; three-forked, and the upper fork hooked. 8. *C. axis*, Lin. *Axis*, or *Gangetic stag*. Pale rufous brown, spotted with white; horns round, slender, erect, with bifid or trifid summits. 9. *C. porcinus*, Lin. *Porcine deer*. Brown above, ash-coloured beneath, with slender trifid horns. 10. *C. Mexicanus*, *Mexican roe*. Red, with rough trifid horns bending forward. 11. *C. pygargus*, Lin. *Tailless roe*. Tailless; brown above, yellow beneath, white behind, with trifid horns, and the nose surrounded with black. 12. *C. Virginianus*, Lin. *Virginian deer*. Pale-brown, with slender, round, branched horns, bending forward, and slightly palmated at the top. 13. *C. Guinensis*, Lin. *Grey deer*. Grey above, black beneath. Azzara has particularized two or three other species, but not with such technical discrimination as to enable us to arrange them in the present nomenclature.

* *C. elaphus.* The stag varies, both in size and colour, in different countries; but its mean height is about three feet and a half, and its general colour reddish-brown above, and whitish beneath, with some black about the face, and a list of the same down the hind part of the neck, and between the shoulders. The greatest known weight of a British stag is that of one which was killed in Aberdeenshire, namely, three hundred and eighteen pounds, exclusively of the entrails, head, and skin. It is alleged, that in Bavaria, the animal frequently exceeds this weight. In Siberia, and some parts of America, it is usually of very large dimensions; whereas in China, Corsica, and some other parts of the world, diminutive varieties are found, which, in bulk, scarcely exceed a dog of ordinary size. Individuals also occur of a very dark or blackish-brown, some of a light or yellowish-brown, and some entirely white. The usual number of branches on the horns of a well-grown stag is six or seven; but some have more, and one variety is characterised by the superior amplitude of its horns. In most cases, the males only have horns; and after their sixth year, when they arrive at maturity, they shed them annually in spring, when they seek the most retired places, and feed only during the night. The annual reproduction of these appendages constitutes, in many points of view, one of the most remarkable phenomena of animal physiology. First, it affords a most striking proof of the power of the nutritive process, and of the rapid growth which depends on it in warm-blooded animals; since the horn of a stag, which may weigh twenty-five pounds, is completely formed in ten weeks. Secondly, it exhibits a singular instance of a limited duration of life in a part of the system, entirely independent of the life of the whole. Thirdly, it manifests a change of calibre in particular vessels; for the branches of the external carotids, which supply the horn with nourishment, are remarkably dilated during its growth, and recover their former area when that process has ceased. Fourthly, it bespeaks a peculiar sympathy between the growth of the horns and the generative functions; because castration, or any essential injury of the organs of generation, impedes the increase, alters the form, or interrupts the renewal of the horns. Anomalous instances of the females possessing horns may be found quoted in Stahl's treatise, *De Cornu Cervi deciduo*, Leopold's *Dissertatio de Alce*, and a paper by Hoy, in the second volume of the Linnéan Transactions.

The stag is a native of almost all the temperate parts of Europe and Asia. In America, where it also occurs, it has, like many others of the indigenous animals, gradually receded from particular regions, in proportion to the increase of civilization. In many parts of this island, over which they were once diffused in great numbers, they have also disappeared with the advances of population and culture, or have been replaced by the fallow-deer, whose venison is of a superior flavour, and whose dispositions are more placid and tractable. The red-deer, however, may still be found in the moors that border on Cornwall and Devonshire, in the New Forest, Hampshire, in the woods and hills of Martindale, near Ullswater, on some of the hills of Galloway, and especially in various districts of the Highlands of Scotland. (Plate CCCLVII. Fig. 37.)

The stag, as Buffon has well observed, is one of those innocent and peaceable animals which seem destined to embellish the forest and enliven the solitudes of nature. The elegance of his form, the lightness of his motions, the strength of his limbs, and the branching horns with which his head is decorated, conspire to give him a high rank among quadrupeds, and to render him worthy of the admiration of mankind. He has a fine eye, an acute sense of smell, and an excellent ear. When listening, he raises his head, erects his ears, and receives the sound from a great distance. Before entering a coppice, or other half-covered retirement, he stops to look round him on all sides, and scents the wind, to discover if any object be near that might disturb him. In general, he is less afraid of men than of dogs; and he is never suspicious, or has recourse to the arts of concealment, but in proportion to the molestation which he has experienced. He eats slowly, and has a choice in his aliments; and, after his stomach is full, he lies down and ruminates at leisure, but with more difficulty than the ox, on account of his longer neck. In winter and spring he dispenses with drink; but, during the parching heats of summer he frequents the brooks, marshes, and fountains; and in autumn, he searches every where for water with which to bathe and refresh his body. On account of his fatness, he than swims more easily than at any other time. He leaps still more nimbly than he swims; and when pursued, can readily clear a hedge or pale six feet high. His food varies according to the season; for, in autumn, he searches for the buds of green shrubs, the flowers of broom or heath, the leaves of bramble, &c. during the snows of winter, he feeds on the bark and moss of trees; in mild weather, he browses in the corn fields; in early spring, he goes in quest of the catkins of willows, trembling poplar and hazel, the flowers and buds of the cornel, &c.; in summer, when he has great choice, he prefers rye to all other grain, and the black-berry-bearing alder, (*rhamnus frangula*,) to all other wood. He crops yew, and swallows the viper with impunity; and, in the Hebrides, he has been observed to eat submarine plants. He avoids consorting with the herds of congenerous species, those of the roebuck not excepted. It is likewise worthy of remark, that if the leader of a herd of stags rush on an enemy, or on present danger, the rest immediately follow in a compact band.

During the rutting season, the voice of this quadruped is strong and loud; the male seems to be so transported with passion, that nothing can resist his fury; and, when at bay, he keeps off the dogs with great intrepidity. The female is gravid eight months, and generally brings forth only one at a time, which she is careful to conceal from beasts and birds of prey, and especially from the male, which eagerly seeks to devour it. Against her less formidable opponents, the hind defends her offspring by force; and when pursued by the hunter, she even offers herself, in order to mislead him from the principal object of her concern. She will fly before the hounds for many hours, and then return to her young, whose life she has thus preserved at the hazard of her own.

Notwithstanding the proverbial longevity of the stag, its term of existence is not supposed to exceed 35 or 40, years. When taken young it may be completely domesticated, and even taught to perform various feats. In some cases it has been trained to the purposes of draught and husbandry. The flesh of the fawn affords a wholesome and delicious food; the horns make excellent handles for knives and other instruments; yield in abundance the salt which forms the basis of the spiit of hartshorn; and, when calcined, afford a valuable astringent. The skin is dressed into leather, for breeches, gloves, belts, &c. and the tallow is converted into candles.

* *C. capreolus.* (Plate CCCLVII. Fig. 38.) Length, from nose to tail, about three feet nine inches; the height before, two feet three inches; and behind, two feet seven inches; length of the tail about one inch. The general colour is reddish-brown, more or less deep in different individuals, and the rump is white. The roe inhabits most parts of Europe, as far north as Norway; it also occurs in some districts of Asia, but has not been observed in Africa. Whether it is a native of America seems somewhat doubtful. In England it is long since extinct; but it is still met with in various districts of the Highlands of Scotland. The sexes unite about the begining of August, and again about the end of November; and this last intercourse only proves fertile.

The roe affects the thick foliage of coppices and brushwood. In his figure and movements, he is more graceful and sprightly than the stag; he is likewise more crafty, and derives superior resources from instinct, frequently doubling during the chase, and manœuvering in such a manner as often to escape from the hounds. The female goes five months and a half with young, and usually brings forth two fawns, in the most secret recess that she can find. In ten or twelve days, her young ones are capable of following her; and they remain with her about eight or nine months. These animals live in separate families, and not in herds; and the natural term of their life is supposed to be twelve or fifteen years. They may, to a certain degree, be tamed, but never completely domesticated; the male, in particular, constantly retaining somewhat of his original wildness, and manifesting sudden caprices and antipathies. The young express their want of food by a short, plaintive cry, which is easily imitated by the hunter, and thus often proves fatal to the mother, which, deceived by the sound, will sometimes approach the muzzle of the sportsman's gun.

"In winter," says Buffon, "the roes frequent the thickest coppices, and feed on brambles, broom, heath, the catkins of the hazel, willow, &c. In spring, they repair to more open brushwood, and eat the buds and young leaves of almost every tree. This warm food ferments in their stomach, and intoxicates them to such a degree, that they are easily surprised. They know not whither they are going, and not unfrequently come out of the wood, and sometimes approach flocks of cattle, and the habitations of men. In summer, they dwell in the most elevated coppices, from which they seldom depart, except in very dry weather, when they go to drink at some fountain; for, when the dews abound, or the leaves are moistened with rain, they never drink. They are delicate in the choice of their food; they eat not with avidity, like the stag; and they seldom approach the cultivated fields, because they prefer the berry-bearing alder, and bramble, to grain, or pot-herbs of any kind."

At the age of eighteen months, the flesh of the female fawn is in the highest state of perfection.

* *C. tarandus.* Although the specific character of the rein-deer be taken from the horns, these vary much in respect of length and form, according to age, sex, and other circumstances. The height of a full-grown rein-deer is four feet six inches; the body is thick and square; and the legs are shorter than those of the stag. The colour of the hair, at the first shedding of the coat, is of a brownish-ash, but afterwards changes to a hoary whiteness, except about the eyes, where it is always black. The neck is furnished with long pending hair, which is coarser than on any other part of the body, and resembles a beard. A white ring surrounds the feet just at the insertion of the hoof. The hair, in general, is so thick over the whole body as, even when put aside with all possible care, to conceal the skin; when the hair falls, also, it is not seen to drop from the root, but seems to break short near the bottom; so that the lower part continues to grow, while the upper falls away. The nose, tail, and belly are white; and the real and spurious hoofs are long and black.

Most of the writers who have described the rein-deer have adverted to the cracking noise which it makes when it moves its limbs, a circumstance which leads us to remark, that its hoofs are admirably adapted to motion on a snowy or icy surface, their under part being entirely covered with hair, as the claw of the ptarmigan is with feathery bristles. The hoofs, however, are not only thus protected, but the same necessity which constrains the inhabitants of the polar regions to use snow-shoes, renders the extraordinary width of the rein-deer's hoofs peculiarly convenient; because, if the weight of the animal's body rested on small points, it would be constantly liable to sink too deep: hence, it instinctively uses a hoof of a naturally commodious form in a manner highly advantageous, namely, by separating it when the foot is to touch the ground, so as to cover a large surface of snow; the moment, however, that the leg is raised, the width of the foot becomes inconvenient, especially when the creature is going against the wind; the hoof, accordingly, is immediately contracted, and the collision of the parts occasions the snapping to which we have alluded.

These deer cast their horns annually, and change their hair every spring, when they are lean and weakly. The female begins to breed at the age of two years; goes eight months with young; and usually brings two at a time. She watches them with the most tender solicitude, and allows them to follow her for two or three years. They seldom acquire their full strength till four years, nor out-live the age of fifteen or sixteen.

The habitation of the species, we need scarcely observe, is limited to some of the coldest regions of the globe; and all attempts to rear any of the race in the more temperate latitudes, have hitherto proved abortive. In the rein-deer the Laplander finds a substitute for the horse, cow, goat and sheep; and it may, indeed, be reckoned almost his only wealth; for the milk affords him cheese; the flesh, a savoury repast; and the skin, clothing; of the tendons, he makes bow-strings and thread; of the horns, glue; and of the bones, spoons. In winter the live animal draws his sledge over frozen lakes and rivers, or over the snow which invests the country. A rich Laplander often possesses a herd of more than 1000 reindeer. In autumn, these serviceable quadrupeds are terribly annoyed by a species of gad-fly, which frequently compels them to seek protection in the snows of the loftiest mountains. In summer, they feed on various plants, but, in winter, chiefly on the rein-deer liver-wort, and some of the pendulous mosses which grow on the pine trees. In summer, the deer lose their vigour and swiftness, being much oppressed with the heat, and tortured by swarms of gnats, which sometimes drive them almost to distraction. Their other formidable enemies are the bear, wolf, and glutton, which, however, they occasionally succeed in resisting.

With a couple of rein-deer put to a sledge, a Laplander can travel fifty or sixty miles a day. The sledge is formed somewhat like a boat, having a back board in it for the rider to lean against. It is square behind, projects to a point in front, and has a convex bottom. The traveller, who is tied in it, like a child in the cradle, manages it with great dexterity, by means of a stick, with a flat end, to remove stones, or other obstructions in the way. The thong by which the animal is yoked is fixed to the peak in front. The bit consists of a piece of narrow leather, tacked to the reins of the bridle over the deer's head and neck; and, from the breast, a leathern strap, passing under the belly, is fastened to the forepart of the sledge, which serves instead of shafts. The vehicle, which is extremely light, is nicely balanced by a careful poise of the body and hands, while the traveller urges the animal by a goad, and encourages it with his voice, often reciting or singing one of his amatory lays.

There is a breed resulting from the wild buck rein-deer and the tame doe, called by the Laplanders *Kaffaigiar*, which is much taller and stronger than the tame one, and consequently sometimes preferred for long journeys; but they retain much of their native wildness, and often prove refractory, at times not only refusing to obey their master, but turning against him, and striking at him with their feet so outrageously, that his only resource is to cover himself with his sledge, on which the enraged quadruped vents its fury.

When taken young, the rein-deer is equally susceptible of domestication as the dog, and will follow its master with great fidelity and attachment.

* *C. alces.* See ELK.

* *C. dama.* The fallow-deer is much smaller than the stag; and its horns, instead of being cylindrical, are broad, palmated at the ends, and better garnished with antlers than those of the stag; the tail is also considerably longer, and the hair is brighter. The fallow-deer is usually of a brownish-bay colour, more or less deep and whitish beneath; but there is likewise a beautiful spotted variety, and some have been found entirely white. In almost every country of Europe this species is found, more or less copiously diffused; but in the cold northern latitudes it is very rare. Its pairing season is a fortnight, or three weeks, later than that of the stag. At that period the males frequently bellow, but with a low and interrupted voice; and they are less furious than the stag. They never quit their pasture in quest of the females, but generally fight with one another, till one becomes master of the field. They usually associate in herds, which sometimes divide into two parties, and maintain obstinate conflicts for some favourite part of the park, each party being conducted by a leader, which is always the oldest and strongest of the herd. They attack in regular order of battle; fight with courage and method; support one another, retiring, rallying, and seldom yielding after a single defeat; the combat being frequently renewed for several days together, till, after repeated discomfitures, the weaker party is compelled to submit, and leave the conquerors in possession of the objects of their contention.

The fallow-deer is easily tamed; feeds on various plants which the stag rejects; is capable of breeding in the second year; arrives at maturity the third, and lives to about twenty. The female goes with young eight months, and produces one, sometimes two, and rarely three, at a time. In every country but Great Britain, they roam freely in the state of nature. Their uses are similar to those of the stag; and their flesh is esteemed much finer venison.

II. SUBSECTION. *Head of the males and females armed with permanent horns, formed by conical protuberances of the frontal bone, which are never deciduous, but covered with a skin that is furnished, especially at the extremity, with very long hairs.*

1. Genus CAMELOPARDALIS, Lin. &c. Eight broad cutting teeth in the lower jaw, the last, on each side, deeply bilobated; neck very long; legs, especially the fore ones, much elevated; breast callous; tail of a moderate length; hair smooth.

* *C. giraffa*, Lin. *Giraffe.* (Plate CCCLVII. Fig. 40.) This singular quadruped, whose existence was once believed to be fabulous, is, in its fore-parts, the tallest of its class, measuring, from the top of the head to the fore feet, from fifteen to sixteen feet; the great height of the shoulders, compared with the thighs, and not, as Buffon alleges, the inequality of the legs, occasioning the marked disproportion between the anterior and posterior parts. The general appearance of the animal, however, is not destitute of picturesque effect, the head being small, and somewhat like that of the stag; the aspect is mild; the eyes are large and animated; the neck extremely long and tapering, and the disposition of the colours singular and pleasing, many squarish brown spots being scattered over a whitish ground. The male and female resemble each other when young, but, as they advance in age, the spots on the former become dark-brown, while those on the latter continue of a ferruginous cast. In both, however, some occasional differences of shade take place; and the female, when very old, is said to acquire the dusky hues of the male. From the head to the middle of the back runs a short stiffish mane, the tail is cylindrical, of moderate length, gradually tapering towards the end, and terminating in a tuft of long hair. The hoofs are moderately large and black. The horns are about half a foot in length. Between the eyes there is a very prominent bony elevation, covered with hair; and there are two smaller protuberances in the occiput, namely, one on each side of the origin of the mane. The fore-part of the body is very thick and muscular, and the hind part thin and meagre, so that when the animal is viewed in front, none of the rest of it is visible.

The giraffe is chiefly a native of Ethiopia; but it also occurs in other parts of Africa, and even of Asia. At the Cape of Good Hope it is not very uncommon. It is also found as far in the interior of Africa as Senegal; but not, as some allege, in Guinea. It is rarely taken alive, except when young. It is of a mild and timid disposition, but is capable of repelling its enemies by severe and repeated kicks. When pursued, it trots, or rather ambles so fast, that even a good horse is scarcely able to keep pace with it, especially on sharp and rough ground, over which it moves with perfect ease It feeds principally on the leaves and tender branches of trees. When it grazes, which seldom happens, it is obliged to separate its legs to a considerable distance, which gives it an awkward air. Small groups of this species, consisting of six or seven individuals, have been repeatedly observed; but, when disturbed, they run off and disappear with wonderful expedition. The female is said to go twelve months with young, and to bring forth only one at a time.

The ancient Romans were not unacquainted with the giraffe, which seems to have been first publicly exhibited to them in the Circæan games by Julius Cæsar. On the Prænestine pavement it is delineated both in its grazing and browzing attitude. Heliodorus, the Greek bishop of Sicca, makes mention of it in his time; and his description of it is more original and authentic than those of most of the old writers.

The flesh, especially of the young animal, is reckoned very tolerable food; and the bones are filled with marrow, which is greatly prized by the Hottentots. Of the skins they make vessels in which to keep water; and it is chiefly for the sake of the marrow and the hides that they hunt and shoot them with poisoned arrows.

III. Subsection. *Head armed with hollow and permanent horns, formed by a bony protuberance of the skull, and invested with a peculiar substance of the nature of nails and hoofs.*

1. Genus Antilope, Lin. &c. The habit of the deer tribe; hair smooth; no beard; horns cylindrical; most frequently ringed at the base; at first upright, and then assuming various inflexions; in many instances lachrymal vessels, or *pori ceriferi*. Resident in the old continent.

The antelopes, which were formerly classed with the goats, form a very numerous family; but the characters of some of the species seem not to have been very distinctly appreciated. In general, they possess considerable elegance of form, are timid and vigilant, but lively, extremely active, and almost elastic in their agile movements. In the midst of their course they will stop for a moment to gaze at their pursuers, and then resume their flight. In the countries which they inhabit, their fleetness is proverbial, and frequently surpasses that of the swiftest greyhound. Hence falcons are sometimes trained to seize on them, and impede their motions, in order to give the dogs an opportunity of overtaking them. Some of the species associate in herds of two or three thousand, whilst others keep in small parties of only five or six. Most of them reside in hilly countries, but some inhabit the plains. They often browze like the goat, and feed on the tender shoots of trees, which gives to the flesh of such of them as are killed in the chace an excellent flavour, but those which are fattened in houses are by no means so delicate. The hunting of these animals is described under the article Antelope.

With horns bent forward.

1. *A. dama*, Lin. *Swift antelope*, or *Nanguer*. Body white; a tawny stripe on the back and eyes; horns hooked forward at the end. 2. *A. redunca*, Lin. *Red antelope*, or *Nagor*. Red-brown, with slightly ringed horns, recurved forward at the tip. * 3. *A picta*, Lin. *White-footed antelope*, or *Nylghau*. Crown and neck maned; tail long and bushy; legs ringed with black and white; horns bent forward. 4. *A. sylvatica*, Lin. *Wood antelope*, or *Bosbok*. Brown above, white beneath; hind part of the body spotted with white; horns spiral and ringed. *A. tragocamelus*, Lin. *Indostan antelope*, or *Biggel*. Grey, with maned neck and breast; a dorsal protuberance; long, flocky tail, and tapering horns bending forward.

With horns recurved backwards.

6. *A. leucophæa*, Lin. *Blue antelope*, or *blue goat*. Body bluish; horns recurved, annulated, and roundish. 7. *A. bubalis*, Lin. *Cervine antelope*, or *hartebeest*. Body reddish-brown; head large, and lengthened; horns thick, strong, and wrinkled; tail somewhat long. 8. * *A. gnu*, Lin. *Ox-headed antelope*, or *Gnou*. Body ferruginous-brown; neck maned; tail whitish; horns directed forward, and then suddenly backward. 9. * *A. rupicapra*, Lin. *Chamois*. Body brown; horns smooth, upright, with the extremities hooked backwards. 10. *A. equina*, Geoff. *Equine antelope*, or *osane*. Rufous-grey; head brown; a white spot in front of each eye; with a mane on the neck.

With straight horns.

11. *A. gazella*, Lin. *Gazelle*, *algazel*, or *algazel antelope*. Body bay; horns tapering and wrinkled. 12. *A. oryx*, Lin. *Egyptian antelope*. Body grey; face black and white; dorsal stripe dusky; horns very long, tapering, and sharply annulated. 13. *A. oreotragus*, Lin. *Klipp-springer*. Yellowish-tawny above; white beneath; horns straight, upright, tapering, and slightly wrinkled at the base. 14. *A. oreas*, Lin. *Indian*, or *elk antelope*. Body grey; horns straight, tapering, and spirally carinated. 15. * *A pygmæa*, Lin. *Pigmy*, or *royal antelope*, or *guevei*. Body bay; horns straight, short, convex, and wrinkled at the base. 16. *A. grimmia*, Lin. *Guinea antelope*. Yellowish-bay, with short horns, and a black bristly tuft on the forehead. 17. *A leucoryx*, Lin. *White antelope*. Body milk-white; horns very long, nearly straight, tapering, and slightly annulated about half-way up.

With horns bent like a lyre.

18. *A. dorcas*, Lin. *Barbary antelope*. Horns lyre-shaped; body tawny above, white beneath; lateral stripe brown. 19. *A. kevella*, Lin. *Flat-horned antelope*, or *kevel*. Tawny-brown above, white below; with a brown lateral band; and compressed lyrated horns. 20. *A. corinna*, Lin. *Corinne*. Fulvous-brown above, white beneath, with dark lateral band, and sub-lyrated, smoothish horns. 21. *A. orientalis*, Erxleb. *Ahu*, *tzeiran*, or *Eastern antelope*. Rufous above, white beneath; ears very long and pointed; tail terminating in a tuft of hair. 22. *A. lerwia*, Lin. *Gambian antelope*. Reddish, with the nape of the neck bearded. 23. *A. koba*, Erxleb. *Kob*. Body obscurely rufous above, dingy white beneath; horns flattish on the sides, with eleven or twelve rings. 24. *A. dorsata*, La Cépède, *A. marsupialis*, Zimmermann, *Opossum antelope*. Rufous-brown above, white beneath, with the semblance of a dorsal pouch near the rump. 25. *A. scripta*, Lin. *Harnessed antelope*, or *guib*. Body of a chesnut hue, with white crossed bars on the sides. 26. *A. saiga*, Lin. *Saiga*, or *Scythian antelope*. Yellowish-grey, with distant and semitransparent horns. 27. *A. gutturosa*, Lin. *Chinese antelope*. Tawny above; whitish beneath; throat prominent, especially in the rutting season. 28. *A. subgutturosa*, Lin. *Güldenstadt's antelope*. Grey-brown above; white beneath; throat somewhat tumid. 29. *A. saliens*, La Cep. *Springbok*, or *leaping antelope of the Cape*. Yellowish-tawny above; white beneath; tail tipped with black. 30. *A. pygarga*, Lin. *White-faced antelope*, c.

springer. Ferruginous-brown above; white beneath; with a brown lateral band; and white rump.

With horns bent in a threefold direction, and spirally twisted.

31. *A. cervicapra*, Lin. *Common antelope.* Tawny-brown above; white beneath; horns round and annulated. 32. *A. strepsiceros*, Lin. *Striped antelope*, or *condoma.* Reddish-grey, with white, longitudinal, dorsal, and transverse stripes.

A few other species are mentioned by different authors, but not with sufficient precision to enable us to note their technical distinctions. It is, however, not improbable, that several remain to be described. Geoffroi, in his enumeration of the family, includes the *fasciata*, which is striped somewhat in the manner of the zebra; but the structure and disposition of its horns are not particularized.

* *A. picta.* (Plate CCCLVIII. Fig. 41.) The height of this species is about four feet, which is also its average length; and the circumference, immediately behind the shoulders, is about four feet ten inches. The general aspect of the animal partakes of those of the ox and deer tribe. The hair on the body is, for the most part, thinner, and more bristly than on our black cattle; but on the belly, and upper parts of the limbs, it is longer and softer than on the back and sides. Along the ridge of the neck and back, as far as the hinder part of the hump, which is over the shoulder blades, the hair forms a short, thin, and upright mane. The belly, inside of the thighs, and all those parts which are covered by the tail, are white. The neck is long and slender; at the throat there is a shield-like patch of beautiful white hair; and lower down there is a mane-like tuft of long black hair. The legs are small in proportion to their length. The female differs so much from the male, that we should scarcely suppose them to belong to the same species. In her inferior size, and yellow colour, she resembles deer, and has no horns. She has four nipples; is supposed to go nine months with young; and commonly has one, though sometimes two, at a time. The young male resembles the female in colour, and is not unlike a fawn. When they meditate hostilities, they fall down on their fore-knees, and push their antagonists with great violence.

At all the places in India, where we have settlements, these animals are rarities, being brought from the remote interior parts of the country, as presents to nabobs and great men. The few individuals which have been conveyed to this country, were principally fed on oats, grass, and hay, and especially on wheaten bread, to which they betray a great partiality. As their manners are, in general, mild and gentle, and they are capable of breeding in this country, they may probably, one day, form an important addition to our stock of grazing quadrupeds.

* *A. gnu.* (Plate CCCLVIII. Fig. 42.) This is a very remarkable species, uniting the strong head and horns of the bull with the lightness and skin of the stag, the beauties of the mane, body, and tail of the horse, and the lachrymal furrows of the antelope. When fully grown, it equals or exceeds the stag in size; and, besides the particularities to which we have just alluded, it is distinguished by very long black hairs, hanging from the breast, and by a strong beard on the chin and throat. The female is said to be horned like the male; and, in the young, the horns are quite straight. The gnous live in great herds in the country of the Nimiquas. Though fierce and formidable, they are hunted on account of their flesh, which is reckoned excellent venison.

* *A. rupicapra.* (Plate CCCLVIII. Fig. 43.) This is one of the few of the antelope tribe that is a native of Europe, occurring in the Alps of Switzerland, Savoy, and Italy, the Pyrenean mountains, the hilly districts of Crete, &c. It is about the size of the common goat, to which it also bears a considerable resemblance; but its under jaw is less prominent; its limbs are rather thicker; the horns are more slender and upright; and the beard is wanting. At the back part of the base of each horn is a pretty large orifice, destined, it has been alleged, to aid respiration; but, as it penetrates not beyond the skin, it can have no reference to that important function, nor, indeed, has its use been hitherto ascertained. The horns of the female are smaller than those of the male, and less curved at the tip. The face is whitish yellow, with two stripes of black on each side. The eyes are round and sparkling. The hair which covers the body is, in summer, short and close, like that of the stag, while, in winter, it is thicker and longer than that of the goat. Its colour, too, varies according to the season, being of a cinereous grey in spring, of a rufous brown in summer, of a fawn-colour, mixed with black, in autumn, and of a blackish-brown in winter.

The chamois has scarcely any cry, unless we may so denominate the feeble bleat by which the parent calls its young. In cases of danger, however, or to warn the rest of the flock, it has recourse to a hissing noise, which is heard at a considerable distance, the male uttering it more loudly and sharply than the female. They feed on the best herbage, and select the most delicate parts of the plants, flowers, and tender buds; evincing a particular fondness for some of the most aromatic mountain-herbs, especially the *carlina* and *genipi.* In winter, they scrape away the snow, to get at the rein-deer moss, and browze on the saplings of pine and fir. When they pasture on succulent herbage, they drink very little: and they ruminate during the intervals of feeding.

These animals are a gentle, vigilant, and gregarious race, occupying the crags of mountains, in flocks consisting of from four to eighty, or even a hundred. The large males feed detached from the rest, except from the beginning of October to the end of November, when they approach the females, and drive off the young; and the dams bring forth in March and April. They are supposed to live twenty or thirty years. They pasture morning and evening, but seldom during the heat of the day; and, in summer, they seek the coolest situations. With great ease, and seeming indifference, they run along the rocks, leaping from one to another; so that no dogs are able to pursue them. Without much apparent effort, they climb and descend precipices, which, to most other quadrupeds, are inaccessible. They mount or descend in an oblique direction, and will throw themselves down thirty feet of a rock, and alight on some shelf or fragment just large enough to support their feet. In their descent, however, they twice or thrice strike the rock with their feet, to impede the velocity of their motion. Their limbs, too, are formed for this arduous kind of exercise; for the hind are longer than the fore legs, and bend in such a manner as to break the force of the fall, in alighting.

Among the Swiss Alps, the chamois hunter usually sets off in the night, that he may reach the more elevated pastures by day-break, before the cattle, a period when the chamois frequently visit them. The moment that he descries a spot where he expects to meet with prey, he examines it with his pocket telescope; but, if he perceives nothing, he mounts still higher; or, if he discovers any, he endeavours to get above them, and to approach them by creeping along some ravine, or gliding behind some rock or eminence. The instant that he can distinguish their horns, he rests his rifle on a rock, takes his aim with astonishing coolness, and rarely misses his object. If he knocks the animal down, he runs up to it, cuts the tendons of its legs, ponders on the most eligible way of returning to his village, and takes along with him either the hide or the whole carcass, according as his road is likely to prove more or less practicable. If he succeeds in fetching home the body on his shoulders, he and his family regale themselves on the flesh, while the skin is dried for sale. But if, as more frequently happens, the wary animal perceives the approach of the hunter, it darts off, with the greatest precipitancy, into the glaciers, or flies to the most abrupt and rugged cliffs. It is especially difficult to get within range when several of them are collected together; for then one of them, which keeps watch on the point of some rock that commands all the avenues to the feeding-ground, hisses when it discovers any object of apprehension; the most experienced of the group scampers off, and the rest accompany him to the most inaccessible retreats. Here commence the fatigues and the peril of the hunter, who, dragged along by his passion for the chase, traverses unmeasured tracts of snow, regardless of the abyss that may yawn beneath, or gets involved in the mazes of the mountains without reflecting on the means of his extrication. Night often arrests him in the midst of his career; but, flattering himself that it will also arrest the object of his pursuit, he sits down at the side of a rock, where, in solitude and silence, without fire or light, and often without shelter of any description, he pulls from his bag a bit of cheese, and a morsel of very hard oaten bread, of which he makes his repast; puts a stone under his head, falls asleep, and dreams of the direction which the chamois has followed. He awakes early in the morning, chilled with cold; surveys the precipices which he has to clear; drinks a little brandy, of which he always carries a small provision; puts his bag on his shoulder again, and sets off to encounter fresh hazards. Thus will these hunters remain, for several days together, in frightful solitudes, while their relatives are doomed to the most cruel anxieties. Their wives dare not even sleep, for fear of seeing them in their dreams, which, according to their superstitious notions, is equivalent to a visit from the departed spirit of their husbands, to indicate the spot where they perished, and to request the person who was dearest to them in life to pay them the rites of burial. "I was acquainted," says Saussure, "with a young man of the parish of Sixt, well made, of a prepossessing countenance, and who had just married a beautiful woman. In the course of his conversation with me on this subject, he thus expressed himself: 'My grandfather died in the chase; my father also died in it; and so fully persuaded am I that I too am destined to a similar fate, that I call this hunting-bag, which you see, Sir, my winding-sheet, because I am certain that I shall have no other: and yet if you would make my fortune, on condition of my renouncing the hunting of the chamois, I could not consent to it.' I have made some excursions in the Alps with this man, and had occasion to remark his astonishing dexterity and address: but his temerity surpassed his strength; and I was informed, that, two years afterwards, his foot slipped on the edge of a precipice, and he experienced the lot which he had predicted.

"The few who grow old in this occupation bear stamped on their visage the characters of the life which they have led; a fierce, wild, and hideous air, distinctly marks them in the midst of a crowd, and even when divested of their appropriate garb. And it is doubtless this unfavourable expression which induces some superstitious peasants to believe that they are conjurors; that, in these deserts, they hold converse with the devil, and that it is he who casts them headlong over precipices."

The flesh of the chamois, especially of the young animal, is very tolerable venison. At Bareges, and the neighbouring watering places, it is frequently served up at table, under the provincial name of *ysard*. In the Alps, the race has been much thinned by the unconquerable perseverance of the hunters, and the demand for the skin, which formed the original *shammoy*, or *shammy* leather, so much prized for its softness and warmth. At present, however, leather so donominated is also prepared from the skin of the tame goat, sheep, and deer.

* *A pygmæa.* This is the most diminutive known species of antelope, being only nine inches high, and frequently confounded with the pigmy musk, which it resembles in size, colour, and manners. It is extremely lively and active, and capable of leaping to the height of twelve feet. It is a native of the hottest parts of Africa, and too delicate to bear the passage to Europe. The horns are only two inches long, and the legs scarcely larger than a goose's quill. The female is said to be hornless. The flesh of this little elegant quadruped is reported to be one of the most exquisite delicacies that can be presented on the table of the epicure.

2. Genus Capra, Lin. &c. Compressed and transversely wrinkled horns in both sexes; no lachrymal vessels; a beard under the chin; hair long; tail short.

* 1. *C. hircus*, Lin. *Common* or *domestic goat.* Horns bent, carinated, generally turning outwards near the tips. 2. *C. ægagrus*, Lin. *Caucassian ibex*, or *Wild goat.* Grey-brown above, white beneath; horns large, bent, carinated, and slightly wrinkled; throat bearded. * 3. *C. ibex*, Lin. *Ibex*, *Ibex goat*, *Steinbock*, *Rock goat*, &c. Grey-brown above, whitish beneath; horns large, knotted, bending over the back; throat bearded.

* *C. hircus.* The goat, in its domestic state, is found in almost every quarter of the globe, bearing the extremes of heat and cold, and differing, in size and form, according to various circumstances. It was, however, entirely unknown to the inhabitants of America on the discovery of that continent; and it is even alleged, that it was introduced into Great Britain from the east. "The origin of the domestic goat," says Mr. Pennant, in his British Zoology, "is the steinbock, ibex or wild goat, a species now found only in the Alps and Crete." The facts stated in the history of *Capra ibex* clearly prove this writer to have been mistaken with respect to

the limited locality of the animal. To ascertain the truth of the other part of his observation in a satisfactory manner, is scarcely to be expected. Pallas allows, that *Capra ibex* may have been the original model from which the domestic kind is derived; at the same time he is inclined to think, and with equal propriety, that *Capra ægagrus*, the Caucassian ibex of Pennant, may have been the primitive source; and this latter notion has been adopted by Gmelin, although we can perceive no very urgent necessity for the adoption of either hypothesis. Buffon, again, considered *Capra ibex*, the chamois antelope, and the domestic goat, as one and the same species; but none, we believe, even of the French naturalists, are disposed to acquiesce in such an improbable supposition.

"The goat," says Buffon, "is superior to the sheep, both in sentiment and dexterity. He approaches man spontaneously, and is easily familiarised. He is sensible of caresses, and capable of a considerable degree of attachment. He is stronger, lighter, more agile, and less timid than the sheep. He is a sprightly, capricious, wandering, wanton animal. It is with much difficulty that he can be confined; and he loves to retire into solitude, and to climb, stand, and even sleep, on rugged and lofty eminences. He is robust, and easily nourished; for he eats almost every herb, and is injured by very few. His bodily temperament, which in all animals has a great influence on the natural dispositions, is not essentially different from that of the sheep. The two animals, whose internal organization is almost entirely similar, are nourished, grow, and multiply in the same manner; and their diseases are the same, excepting a few to which the goat is not subject. The goat fears not, like the sheep, too great a degree of heat. He cheerfully exposes himself to the sun, and sleeps under his most ardent rays, without being affected by vertigo, or any other inconvenience. He is not afraid of rain or storms, but he seems to feel the effects of severe cold. The inconstancy of his disposition is marked by the irregularity of his actions: he walks, stops short, runs, leaps, approaches, or retires, shows or conceals himself, or flies off, as if actuated by mere humour, and without any other cause than what originates in an eccentric vivacity of temper. The suppleness of his organs, and the strength and nervousness of his frame, are hardly sufficient to support the petulance and rapidity of his natural movements.

"When pastured along with sheep, goats always take the lead of the flock. They love to feed separately on the tops of the hills, and prefer the most elevated and rugged parts of mountains. They find sufficient nourishment in heathy, barren and uncultivated ground. They do infinite mischief when permitted to go among corn, vines, copses, or young plantations; for they eat with avidity the tender bark and young shoots of trees, which generally proves fatal to their growth. They carefully avoid moist ground, marshy meadows, and rich pastures. They are seldom reared in plain countries, where they never thrive, and where their flesh is always bad."

When, to prevent their straying too far from home, two of these animals are coupled, they will, as it were by mutual consent, take the most dangerous leaps together, and exert their efforts in such perfect unison, that they generally accomplish their purposes unhurt. Their dispositions, when improved by culture, are, for the most part, sufficiently mild; but their passions are frequently roused on a sudden, when they betray ill-nature, and butt at the offender with great violence. Their smell is always powerful, and, at one season of the year, particularly in the months of September and October, highly offensive. This odour, which is not unaptly represented by that of *Geranium robertianum*, is believed to act as a preventive of disease in horses; and, on this account, goats are often kept about the stables of inns, and of those persons who have extensive studs. The females sometimes produce three, more rarely four, but most usually two, at a time; and their period of gestation is about eighteen weeks. In our climate, goats are seldom known to live beyond eleven or twelve years. The goat will breed with the sheep, and their offspring breed again; but no new race results from this anomalous intermixture.

In some parts of the continent of Europe goats very materially contribute to the wants and comforts of the lower classes of the peasantry; because, though fed only on the most neglected and uncultivated spots, they yield abundance of milk and cheese. The milk, which affords little cream, is sweet and salutary, and is frequently recommended in phthisical complaints. Although, to persons unaccustomed to eat it, neither the smell nor the taste of goat's flesh is agreeable, it nevertheless furnishes the inhabitants of highland countries with a cheap and plentiful article of food. The meat of the spayed goat, of six or seven years old, is generally sweet and fat, and passes under the name of *rock-venison*; but that of the kid is by far the best, and is by many preferred to lamb. The skin of this species is particularly well adapted to the glove-manufacture. Abroad, it is dressed, and made into stockings, bedticks, bolsters, bed-hangings, &c. In the army, it covers the horsemen's arms, and contains the foot soldier's provisions. As it takes the dye better than any other skin, it was formerly much used for hangings in the houses of the opulent. In Turkey and the Crimea, it is still preferred by the manufacturers of morocco leather. The whitest wigs are made of goat's hair, baked and bleached; and very fine shawls might be manufactured from the soft kind of wool which grows at the roots of the long hair of that variety which furnishes soldiers' knapsacks.

The Syrian and Angora goats may be regarded as only elegant varieties of the more common species. "It is not to the atmosphere of Angora," observes St. Pierre, "that we are to attribute the fineness, the length, and the gloss of the goat's hair, of which the Turks make their magnificent camlets; nor to its rocks, which, notwithstanding my supposition in the *Studies of Nature*, have no existence, but to the long and silky dog's grass produced through its vast plains. I owe this observation to Busbeck, the well-known traveller, to whom Europe is indebted for the lilac imported from the East, and whose authority is deserving of particular attention."

Most of the European nations have agents for purchasing the valuable wool of these animals, which the Turks, it is alleged, will not allow to be sent out of their country in a raw state, but in the form of thread, as multitudes of the poorer orders obtain a livelihood by spinning it. The most considerable manufacture of camlets fabricated with this wool in Europe appears to be that of French Flanders, and which is principally carried on at Lille and Amiens.

* *C. Ibex.* (Plate CCCLVIII. Fig. 44.) The *ibex*, or *bouquetin*, is found in several parts of Europe and Asia,

as in the Alps, Pyrenees, Carpathian mountains, Mount Taurus, the tracts beyond the Lena, &c. From several districts of the Alps, it is supposed to have been nearly exterminated by the hunters, who are no less daring and resolute than those of the chamois. The male, in outward form, much resembles the goat, but is larger, has a smaller head in proportion to its dimensions, with the eyes large, round, and fiery; the horns, when of a full size, are large and heavy, flattened before, and rounded behind, with one or two longitudinal, and many transverse ridges. The beard is long, tawny, or dusky; the body is short, thick, and strong, covered with a long, but not pendent coat, marked with a black dorsal list. The legs are slender, and the hoofs are terminated, like those of the chamois, by a salient border. The female is one-third less than the male, and not so corpulent; her colour, too, is less tawny, and her horns are much smaller. She has two teats, but no beard, except, occasionally, in advanced age. She goes with young from about January till June, or July, when she separates from the male, seeks retirement by the side of some rill, and produces one, or, sometimes, two young.

The bouquetin will mount a rock of fifteen feet in height at three successive leaps, or rather bounds, apparently touching the surface as if merely to be repelled, like an elastic substance striking against any hard body. He also, when pursued, traverses the glaciers with great rapidity, but, otherwise, he rather avoids them. Small flocks of this species seldom consist of more than twelve or fifteen, feed, during the night, in the elevated woods, in which they also reside during winter, and to which they betake themselves for shelter during a storm. In fair summer weather, they quit the woody regions during the day, and feed, in their progress towards the loftiest summits, gradually descending again at the approach of evening. Their common cry is a short sharp whistle, not unlike that of the chamois, but of less continuance. Sometimes they snort, and, when young, they bleat. They are in best condition in the months of August and September, which is the usual season of hunting them; but the occupation is attended with uncommon toil and hazard. The flesh of the young is much esteemed as an article of food.

3. Genus Ovis, Lin. &c. In both sexes horns which exhibit an angulated section, directed backwards, and downwards near their base, and then rising in a semicircular form; no lachrymal vessels; wool or hair on the skin; tail of moderate length, or very short, and often very thick; no beard under the chin. Resident in both continents.

The animals belonging to this genus, in respect of agility, are very inferior to the goat, from which they also differ in their mode of fighting, not rising on their hind legs, but butting against each other with their horns, and threatening, and stamping on the ground with their feet. In general, however, they are shy, timid, and harmless. The female goes with young about five months, and usually produces one, sometimes twins, and, rarely, three at a time. Their age seldom exceeds fourteen or fifteen years. All kinds of sheep are partial to dry and open plains, and grassy, or heathy hills, their favorite food consisting of the short and sweet grasses, which grow spontaneously in such situations, and which they crop quite close to the ground. They are averse to marshy soils, and are said to require less water than most ruminating quadrupeds.

Of the common species of sheep, as of most domesticated animals, the varieties are both numerous and striking. In general, their coat, or fleece, consists of wool; but there is an African sort that is clad in hair. The Icelandic variety has often more than two horns, while several of the British breeds are hornless. In some parts of Africa the sheep have long slender tails, in others, this appendage is of uncommon breadth and thickness, and prevented from trailing on the ground by artificial means. Another singular variety, again, termed the *fat-rumped*, is characterized by the want of tail; and the presence of two large cushions of suet on the hinder extremities. The *Pudu* of America has smooth, round, and diverging horns. The *Wallachian* or *Cretan* breed, is chiefly distinguished by its large, upright, curiously twisted, and carinated horns, and of long shaggy fleeces. Nor should we omit to mention the *Musimon* of Pliny and Gesner, *Ovis ammon* of Linné, *Mouflon* of Buffon, *Wild-sheep* of Pennant, and *Argali* of Shaw, &c. an animal which some naturalists regard as a distinct species, and others as the primitive source of all the ovine tribe. By others, it has been reckoned more nearly allied to the goat. Its general size is that of a small fallow-deer; its colour greyish, ferruginous brown above, and whitish beneath. The tail is remarkably short; but the horns, in the full-grown animal, are extremely large, placed on the top of the head, standing close at their base, rising first upwards, then bending down, and twisting outwards, as in the common ram. The body is covered with hair instead of wool; and on the neck, are two pendent hairy dewlaps. It chiefly inhabits the rocky and mountainous districts of Asia and Greece; and it also occurs, though somewhat modified, in the islands of Corsica and Sardinia.

In the British islands we know nothing of the manners and habits even of the common sort, in a state of nature; for, in every part even of the mountainous wilds of England, Scotland, and Ireland, these animals are all private property; and, in their most extensive and remote ranges, they are still under the guidance of shepherds and their dogs.

* 1. *O. aries*, Lin. &c. *Common*, or *Domestic sheep*. Horns compressed, and lunated. The domestic sheep, in its most valuable or woolly state, exists in perfection chiefly in Europe, and some of the temperate tracts of Asia. When transported into very warm climates, it loses its peculiar covering, and appears coated with hair, having only a short wool next the skin. In very cold countries again, the external part of the wool is observed to be harsh and coarse. In other respects, too, the animal is liable to suffer from the extremes of heat and cold. Its existence in a wild and insulated condition is, perhaps, incompatible with its constitutional propensities. But, although much indebted to human care for its preservation and diffusion, we cannot allow that it is the inanimate senseless creature described by Buffon, who represents it as devoid of every art of self-preservation; destitute of courage; deprived of every instinctive faculty; as, in short, the most contemptible and stupid of all animals. Among those numerous flocks which roam on the mountains, and are conscious of a more precarious dependence on the shepherd's aid, a ram, or a wedder, will boldly attack a single dog, and often prevail against him. When danger is more urgent or alarming, recourse is had to the collected strength of the whole flock. On such occasions they draw up in a compact body, placing the young and the females in the centre, while the males take the foremost ranks, and keep close by

one another. Thus an armed front is presented in all directions to the assailant. In this attitude they wait with firmness the approach of the enemy ; nor does their courage fail them in the moment of attack ; for, when the aggressor advances within a few yards of the line, the rams dart on him with such impetuosity, as to lay him dead at their feet, unless he betakes himself to flight ; so that against the attacks of single dogs and foxes, they are, when in this situation, perfectly secure. Nay, a ram, as if wholly regardless of danger, will sometimes encounter a bull ; and, as the latter, by lowering his head, receives the stroke between his eyes, he is, not unfrequently, brought to the ground. Nor is the sheep deficient in that sagacity which is requisite for the selection of its food, or in that dexterity and cunning by which it occasionally attempts to elude the vigilance of the shepherd, in order to steal such delicacies as are agreeable to its palate. On the hardiness with which it endures great severities of weather, its prescience of an impending storm, its fondness of jingling sounds, and its decided social propensities, we need not enlarge, as they must be obvious to the most ordinary observer. Neither need we minutely dwell on its various and important uses in an economical and commercial point of view, as every part of it is subservient to some useful purpose or other, the flesh supplying us with wholesome and palatable nourishment ; the milk affording a large quantity of cheese, which is usually much relished in pastoral districts ; the skin, when stripped of the wool, and tanned, being in great request, particularly by bookbinders and saddlers ; the entrails being converted into strings for various musical instruments; and the bones, when calcined, being used as tests for the refiner. The fleece, we need hardly mention, affords clothing to myriads of the human race. In this island, in particular, the woollen manufactures form a national staple of industry and wealth ; and the utmost attention has been bestowed on crossing and improving the various breeds of sheep. The present annual value of wool shorn in England, is supposed to be about 5,000,000*l.* sterling ; of that imported from Spain, about 600,000*l.* and of the whole, when reduced to the manufactured state, 21,000,000*l.* They who are possessed of the best information on the subject have calculated the number of fleece-bearing animals in Great Britain and Ireland, at 30,000,000, of which no fewer than between 3,000,000 and 4,000,000 perish every year of disease,—a heavy public loss, which might be greatly alleviated by a careful and enlightened management of this very valuable quadruped. See also AGRICULTURE, COMMERCE, MANUFACTURES, VETERINARY ART, WOOL, &c.

4. Genus Bos, Lin. &c. Horns short, conical, directed laterally, and backward, then rising in a semicircular form, and smooth throughout most of their length ; general figure short and compact ; skin of the neck loose and hanging, forming what is termed a *dew-lap* ; tail pretty long, and usually bushy towards the extremity. Resident in both continents.

The animals of this tribe chiefly occur in flat pastures, their large and unwieldy forms rendering them unfit for frequenting mountainous and woody districts. Although in their native plains, or savannahs, they are sometimes exceedingly wild and savage, yet there are few of them that are altogether incapable of domestication. Their services to mankind are even more considerable than those of the sheep; for, besides the benefit derived from their hides, flesh, and milk, they are employed as beasts of draft and burthen. Their voice is termed *lowing* or *bellowing*. They fight by pushing with their horns, and kicking with their feet ; and when they are irritated, their strength and obstinacy are such, that there are few animals which can oppose them singly with much chance of success. Like other races of the inferior animals that have been subjected to human management and control, the bovine presents us with varieties of breeds which graduate into one another, and, also, with intermediate lines and shadings between real or supposed species. Hence, while we note the more ordinary definitions and distinctions, we feel somewhat diffident of the accuracy and precision on which they are grounded.

* 1. ***Bos taurus***, Lin. &c. *Common ox.* Round horns, curved outward, loose dew-lap. * 2. ***B. bubalus***, Lin. &c. *Buffalo* ; horns lying backward, turning inward, and flat on the fore-part. 3. ***B. caffer***, Lin. &c. *Cape ox.* Horns very broad at the base, then spreading downward, next upward, and curving inward at the tips. 4. ***B. grunniens***, Lin. &c. *Grunting ox*, *Yak*, or *Yak of Tartary.* Horns cylindrical, and curved outward ; hair very long and pendant ; tail like that of a horse. 5. ***B. arnee***, *Arnee*, or *Wild Indian Buffalo.* Horns long, erect, semilunar, and wrinkled, tips smooth, round, and approaching. * 6. ***B. moschatus***, *Musk ox.* Hair very long and pendant ; horns of the male approximated at the base, bending inward and downward, and outward at the tips. 7. ***B. Americanus***, *American ox*, *American bison*, *American buffalo*, &c. 8. ***B. frontalis***, *Gyall.* Brownish, forehead grey, or white ; horns thick, remote, short ; tail somewhat naked, with the tip slender and hairy.

****B. taurus.*** The domestic ox, under various modifications, is found in almost every corner of the world, peacefully grazing in meadows, and preferring those which are sheltered, and which yield the richest and most succulent grass. They usually lie on their left side, sleep little, awaken with the least noise, and drink in the same manner as horses. The females, at the age of eighteen months, and the males, when two years of age, are capable of breeding. In our climate, they unite in spring or summer ; the term of gestation is nine months, and the usual produce a single calf. From the period of five to nine years they are most robust and vigorous ; and they seldom survive fifteen years. The first front-teeth are shed in the tenth month, and replaced by others which are less white and broader. Those next to the middle of the row drop in the sixteenth month, and are also replaced by others ; by the third year all the cutting teeth are renewed, and appear equal and pretty white ; but, in the progress of age, they wear down, and become black and uneven. In the earlier editions of his natural history, Buffon had asserted, that, at three years of age, both the bull and the cow shed their horns, which were replaced by permanent ones. This error, which others carelessly copied, he, subsequently, very candidly retracted. It is true, however, that the horns at that period undergo a partial exfoliation ; that, in the fourth year, a ring is formed at their roots, and that, in every succeeding year, another ring is added, thus affording a correct index of the age of the individual.

When cattle are at rest, and neither grazing nor ruminating, they are frequently observed to raise the hair of their coat by licking it, and to swallow it in considerable quantities. This, from its indigestible nature, remains in the stomach, and collects into round smooth balls, which have been known to acquire such dimensions as to impede the performance of the necessary animal functions.

Notwithstanding their massy forms, these animals run with considerable quickness; and, notwithstanding their apparent phlegm and stupidity, they frequently exhibit proofs of no ordinary sagacity; nor are they unsusceptible of attachment, for they readily recognize their homes, and the persons who treat them with attention and kindness. Should a wolf happen to prowl about a herd of cattle that is grazing in a sequestered corner, the cows form a circle, within which the calves are so completely protected, that the wolf dares not invade them; and, if he does not speedily take to his heels, a bull will often advance from the ranks and pursue him to a great distance. They seem likewise to be conscious of impending changes of weather. If abroad, for example, when, after long continued drought, the sky is thickening, and rain approaching, we may frequently observe the cattle stretching their necks, and snuffing in the air with distended nostrils, or before storms assembling in the corner of the field, with their heads to the leeward. There is every reason to believe that the common cow is not insensible to the vanity of distinction and preference. The fine cattle, which are the pride of the *senn*, or the cow-keeper, in certain districts of the Swiss Alps, as, for example, the canton of Appenzel, are adorned with large bells suspended from broad thongs; and every senn has a harmonious set, of at least two or three bells, which are worn only on certain gala or procession days. The senn, arrayed in his best garb, leads the van, singing the *ranz des vaches;* three or four goats follow; then comes the handsomest cow with the great bells; and then the others, with smaller ones. These are succeeded by the rest of the herd; the bull, with a milking stool hanging on his horns, and a sledge, containing the implements of the dairy, bringing up the rear. The cows themselves, no less than their conductor, seem to be pleased with their ornaments; and if the leader is deprived of her honours, she manifests her vexation by incessant lowing, abstains from food, and pursues with vengeance her rival who has obtained the badge of superiority, assaulting and wounding her in the most furious manner. These animals, when dispersed in the Alps, are brought together by the voice of the senn, who allures them to him by singing the *ranz des vaches.*

Although the best food for cattle is good pasturage in the open air, yet, in consequence of their being housed, and subjected to labour, a mixture of harder and more substantial aliment occasionally becomes requisite. Water which is agitated and beaten is to be preferred for their drink, to that which is stagnant; that of rivers, to that of springs; that of pools, to that of marshes; and this last is sometimes less hurtful than that of wells, if the latter is incapable of boiling vegetables. If, however, none but the worst water can be procured, it ought to be previously filtered through sand, and even rendered still more wholesome by mixing with it a little bran or barley-meal. In the heat of summer, especially if the water be not of a good quality, it will be proper to allow a wine glassful of vinegar to every pailful of water; and, in case of inflammatory disorders, which have a tendency to induce gangrene, it is recommended to mix vinegar in the proportion of one-sixth of the whole quantity of drink, whether that be water or whey. At all events, cattle should be allowed water twice a-day, especially when they are fed on dry provender; for negligence in this respect is often the cause of serious maladies. Cattle, like sheep, are extremely fond of salt, and of herbage over which the sea has flowed, repairing statedly to the beach, when it is in their power, during the tide of ebb, and retiring again when the water rises. In some parts of Norway, and other poor countries, bathed by the sea, the cows are often subsisted principally on salt fish or sub-marine plants.

The cow, in its faculty of giving in such abundance, and with so much ease, the contents of its udder, which constitute excellent nourishment for the human species, affords a striking example of the subserviency of some of the inferior animals to the benefit of mankind. This quadruped, in fact, differs, in some part of its organization, from most others, having a large and more capacious udder, and longer and thicker teats than the largest animal with which we are acquainted. We may add, that she has four teats, whilst other ruminants have but two. She also yields the milk freely to the hand, while most quadrupeds, at least those that do not ruminate in the same manner, refuse it, unless their own young, or some adopted animal, be allowed to partake.

A few wild cattle, though perhaps somewhat altered by a crossing of the breed, are still preserved in Lord Tankerville's park, at Chillingham, near Berwick; at Woolerton, the seat of Lord Middleton, in Nottinghamshire; at Gisburne, in Yorkshire, Lime-hall, in Cheshire, Chartley, in Staffordshire, and in the demesnes of the Duke of Hamilton, and the Marquis of Queensberry, in Scotland. These creatures are of a creamy white colour, with the muzzle and tips of the horns black; and about a third part of the outside of the ears red. Some of the bulls have a thin upright mane, nearly two inches long, but they are entirely destitute of that shagginess in front which characterizes the wild breeds on the continent of Europe. Some of the principal British domestic varieties, among the horned, are, the Devonshire, Hereford, Sussex, Holderness, Lancashire, Alderney, Highland, Scottish, Welsh, and Irish; and, among the hornless, the Suffolk duns, Galloway, and Northern or Yorkshire polled. But it would greatly exceed our limits to specify the merits and defects of each, and still more, to advert to the discriminating features and properties of even the the most singular of the foreign European races. If we cast our eyes over the immense extent of Asia, we shall find multitudes of cattle dispersed over its hills and plains, from the confines of the Icy Sea, to the extreme point of the peninsula of Malacca, and from Arabia to Japan. Among these have been noticed some extraordinary varieties, particularly the *zebu*, which has the appearance of a mis-shapen ox, with a fleshy bunch on the shoulders, which, however, is more conspicuous on the male than on the female. The *galla*, or *sanga* oxen, are celebrated, throughout Abyssinia, for the remarkable size of their horns; and they have also a hunch over the shoulders. The horns of an individual of this variety are deposited in the Museum of the College of Surgeons, in London, and a still larger pair in the Earl of Mountmorris' collection. It appears from Mr. Salt's observations, that the extraordinary size of these horns is not occasioned, as Mr. Bruce had too rashly conjectured, by any diseased state of the animal. "The length of the largest horn of this description, which I met with," says Mr. Salt, "was nearly four feet, and its circumference at the base, twenty-one inches."

Since the introduction of the domestic ox into the new continent, it has prodigiously multiplied, both in the north and south of that quarter of the world.

* *B. bubalus.* The head of the buffalo is larger in proportion than that of the ox; the forehead is more elevated; and the muzzle longer, but, at the same time, broad and square. In this species, too, the dewlap is wanting; the tail is more slender than that of the ox, and its ears are longer and more pointed. The teats are disposed in a single transverse line, and not in longitudinal and parallel lines, as in the congenerous species. Thickness of trunk, largeness of limbs, and prominence of muscles, all bespeak the strength and vigour of the buffalo, while the amplitude of its head, and its small eyes, deep-seated in their round sockets, impart to it a wild and stern aspect, which the tuft of frizzled hair on the forehead renders still more dark and sullen. The most ordinary colour of the buffalo is blackish; but the hair on the top of the forehead, and that at the tip of the tail, are of a yellowish-white. The skin itself is also of a black hue, though we meet with descriptions of white, grey, and reddish, or bay buff. The length and thickness of the hair are very variable, and the animal sometimes occurs almost naked.

The buffalo is originally a native of the warmer parts of India and Africa, and is merely one of the introduced or naturalized quadrupeds of Europe. It appears to have been brought into Italy as early as the seventh century, and is still reared in the Pontine marshes and the *maremma* of Siena. Those of Abyssynia grow to twice the size of our largest oxen, and are called *elephant bulls*, not only on account of their ample dimensions, but of their naked and black skin, resembling that of the elephant. They are fond of wallowing in the mud, and will swim over the broadest rivers, sometimes diving ten or twelve feet deep, to force up, with their horns, the aquatic plants which they eat during their passage. Two domestic buffaloes, yoked, or rather chained, to a cart, are able to draw as much as four strong horses. As they carry their head and neck low, the whole weight of their body is employed in drawing; and their mass much exceeds that of a labouring horse. In Egypt, where they are much cultivated, they yield plenty of excellent milk, of which butter and several kinds of cheese are made. In Persia, the island of Sumatra, and other countries in the east, this species has been greatly multiplied for the purposes of labour; but it is more fierce and untractable than the preceding; and it is generally conducted by means of a ring inserted in the cartilage of the nose. The flesh is rather tough, musky, and unsavoury; but, in some countries, is said to be little inferior to beef. That of the calves, in particular, is much relished by the Americans. Of the hide is made strong and durable leather; and the horns are in particular request by cutlers, and other artificers.

* *B. moschatus.* (Plate CCCLVIII. Fig. 45.) This animal is rather lower than the deer, but longer or thicker in the body. The hair of the male is of a dusky red, extremely fine, and so long as to trail on the ground, and to render the animal a seemingly shapeless mass, without distinction of head or tail. The legs are very short; the shoulders rise into a lump; and the tail consists of a very short stump, but furnished with very long hairs. Beneath the general hairy covering, there is a fine cinereous wool, which, when manufactured into stockings, may vie with silk. The horns, near the base, are two feet in girth; only two feet long when measured in the direction of the curvature; and they, jointly, weigh from 50 to 60 lbs. The cow differs from the bull in having the horns much smaller, and placed at the distance of nine inches from each other at the base, of a whitish colour, about thirteen inches long, and eight inches round the base. The general colour is black, but the legs are whitish; and, between the horns, there is a bed of white hair, intermixed with rust colour. A dusky mane runs along the back.

The musk ox is a native of North America, where it appears to be a very local animal, affecting rocks and barren mountains, which it climbs with great nimbleness. The flesh is strongly tinctured with the flavour of musk, but is said to be very wholesome food. The skins, from their superior warmth, make excellent coverings.

ORDER IX. SOLIPEDES.

A single toe on each foot, included in a broad hoof; six cutting teeth, or *nippers*, in each jaw; two very small tusks; grinders with a flat crown, presenting, when worn, different figures, formed by the enamelled plates of their interior; stomach small and simple; intestines very large; a valve at the cardia; the cæcum of considerable dimensions; neither gall-bladder nor clavicles. All resident in the old continent.

1. Genus Equus, Lin. &c. The characters corresponding with those of the order.

* *E. caballus*, Lin. &c. *Horse.* Hoofs undivided; mane and tail with long flowing hair. * 2. *E. hemionus*, *Jickta*, or *Wild Mule.* A longitudinal dorsal stripe, without the humeral transverse band; tail hairy only at the tip. * 3. *E. asinus*, Lin. &c. *Ass.* Hoofs solid; a blackish cross over the shoulders; tail tipped with long hair. * 4. *E. zebra*, Lin. &c. *Zebra.* Hoofs solid; body pale buff, with perpendicular brown bands. 5. *E. quagga*, Lin. &c. *Quagga.* Hoofs solid; body chesnut colour above, with perpendicular brown stripes; belly, legs, and thighs, destitute of stripes, and the sides spotted.

* *E. caballus.* Whether this noble and invaluable quadruped was primarily created with propensities to associate with the human species, or whether he has been merely reclaimed from a savage condition by the cares and control of mankind, it were now perhaps useless to inquire. In various parts of the world, multitudes of the race are certainly found to roam at large; but these, in some cases at least, are undoubtedly descended from domestic generations; and it is no extravagant presumption to suppose, that in no country has the species uniformly retained its absolute freedom and independence. Large herds are occasionally seen in the southern parts of Siberia, in the great Mongolian deserts, and among the Kalkas, to the north-west of China. They are also found in the deserts on each side of the Don; but these last have, it is alleged, been traced to the Russian horses that were employed in the siege of Azoph, in 1697, when, being turned loose for want of forage, they escaped into the deserts, and their progeny gradually assumed the appearance of native wildness. At the Cape of Good Hope there are numbers of unreclaimed horses, but small, vicious, and untractable. They are found wild also in several other

parts of Africa; but the wretched inhabitants of that country either want the art of taming them, or seem to be ignorant of the value of their services. The wild horses in Spanish America are descended from those of the Andalusian breed, which were originally conveyed from Spain by the first conquerors. They chiefly frequent the southern districts of the river Plata, as far as Rio Negro, the country of the Patagonians, &c. living in numerous herds, some of which amount to no fewer than ten thousand individuals. Among these herds, each stallion appropriates as many mares as he can, which he keeps collected and protects, so that the large wandering troops consist of many family parties. In all those troops which d'Azzara had an opportunity of observing, he never remarked any prevailing colour but bay, dark-brown, and black, of which the first is by far the most common. But, of all countries in which the horse runs wild, Arabia produces the most beautiful breed, and also the most generous, swift, and persevering. They occur, though not in great numbers, even in the deserts of that country; and the natives make use of every stratagem to take them. From those which they capture they select the most promising for breeding; and they cherish and cultivate the race with a degree of kindness and attention which can scarcely be surpassed. It is even probable that Arabia was the original country of the horse, since there, instead of crossing the breed, the utmost care is taken to keep it entire. The Arabian race of horses has been diffused in Barbary, Egypt and Persia. According to Mr. Bruce, the horses of Nubia are of unparalleled beauty, surpassing even those of Arabia; but, from the improper mode of feeding them, they are apt to become too corpulent. Without greatly exceeding our limits, however, we cannot venture to analyze the distinctive features and properties of the different breeds of horses which are scattered over the world.

In this island, the frequent introduction of foreign horses has furnished us with a variety of which no single country can boast; while, by a judicious mixture of the several kinds, the differences of our soil, and our superior skill in management, the most valuable qualities of this noble animal have been cultivated to the greatest advantage. In the annals of Newmarket may be found instances of horses which may be said to have outstripped the wind. Thus, the celebrated Childers ran four miles in 6 minutes and 48 seconds, carrying, at the same time, a weight of 9 stone and 2 lb. One of the most remarkable instances of the efforts of post-horses, is that which occurred in 1745, when the postmaster of Stilton rode, on different horses, along the London road, 215 miles in 11 hours and a half, or above 18 miles an hour. As the English saddle-horses unite superior action with strength, proportion, and beauty, they are in high request even in many countries of the continent. The utmost speed of an English trotter is considered to be a mile in about 2 minutes and 57 seconds; a rate which was performed some years ago by Archer, the property of Marsden, the dealer. The London dray-horses are more remarkable for mass and weight than for hardiness or vivacity. The *Suffolk punches*, as they are called, excel in drawing dead pulls. Five of these horses once drew thirty sacks of barley over the sandy road from Walton to Ipswich; and one, belonging to Mr. Constable of East Berghott, drew in a cart ten sacks of flour, each weighing twenty stone and a half, for five or six miles, on a heavy road. The true Lanark or Clydesdale breed of draught-horses, which are lighter in the body than the preceding, are capable of exerting great muscular strength for a short push, without being injured by it, are reckoned peculiarly serviceable in hilly districts, and are not only hardy, but contented with coarse and frugal fare. The mountain poneys of Wales and Scotland, though small, are extremely hardy, durable, and sure-footed. The *shelties*, or dwarf poneys of Shetland and Orkney, though only from nine to eleven hands in height, brave the rigours of our northern winters in the open air, and are excellently calculated for traversing the rugged paths of their native hills.

Of the various modes of judging of a horse's age, the least equivocal is a careful inspection of the teeth. Five days after birth, the four teeth in front, called *nippers*, begin to shoot; they are cast at the age of two years and a half, but are soon renewed; and, in the following year, two above, and two below, one, namely, on each side of the nippers, are also cast; at four years and a half, other four; next, those last placed fall out, and are succeeded by other four, which grow much more slowly. From these last four corner-teeth it is, that the animal's age is distinguished; for they are somewhat hollow in the middle, and have a black mark in the cavities. At five years, these teeth scarcely rise above the gums; at six, their cavities begin to fill up, and turn to a brown spot, like the eye of a garden bean; and, before eight years, the mark generally disappears. A horse's age is also indicated by the tusks; for those in the under jaw usually shoot at three years and a half, and the two in the upper at four; till six, they continue sharp at the points; but, at ten, they appear long and blunted. A practised observer of the general aspect of a horse may guess at its age pretty accurately, as we judge of that of our fellow-men, by the countenance and appearance. In certain situations, the acquisition of such a habit becomes the more desirable, because jockeys have the art of perforating the animal's teeth, and marking the hole with pitch, or some other black substance, so as to impose on the unwary.

At the age of two years, the horse is in a condition to propagate. The mare is generally in season from the latter end of March till the beginning of June; but her most violent ardour for the horse continues only fifteen or twenty days. She goes with young eleven months and some days; continues to breed till the age of sixteen or eighteen years; and lives, on an average, between twenty and thirty years. The foal is capable of taking solid food at four months, and may be weaned at six or seven. In its fourth year, the fore feet may be shod, and the hind feet six months after.

The horse is, strictly speaking, an herbivorous animal, and is somewhat more scrupulous in the choice of his food than most other domestic quadrupeds. In the meadow, for example, he rejects several plants which the ox crops without hesitation. In Sweden, it has been calculated that he eats 262 species of herbs, and rejects 212. Marshy pastures are very unfriendly to his constitution; and he is apt to indulge too freely in succulent herbage, particularly clover and lucern. He is fond of salt, bread, and malt liquors. He sleeps only from four to six hours in the twenty-four, and frequently in a standing posture. He is apt to be easily startled at loud or unusual sounds, and at the sight of unexpected objects, especially of a dead individual of his own species. If properly treated, he may live to forty or fifty years.

In this place, we purposely forbear from entering on the various diseases to which this highly interesting animal is liable, and which are properly considered under the article Farriery. Neither, surely, need we enlarge on his extraordinary sagacity and affection, on his social and gregarious dispositions, his love of home, his wonderful docility, and the harsh and unfeeling treatment which he too often experiences from the caprice of human fashions, and especially from sordid, yet fallacious considerations of gain.

* *E. hemionus.* The term *jicta* is a corruption of the Mongolian *czigitai*, or rather *dshigetei*, which signifies *great ears*. The animal which it denotes is described by Pallas, in the nineteenth volume of the new series of the Petropolitan Transactions, and is supposed by that naturalist to be the *hemionus* of Aristotle. If so, it seems to have remained almost unnoticed since the time of Pliny, who mentions it as a native of Cappadocia. At present, it occurs in the desert regions between the Onon and the Argun, in the southern parts of Siberia, and especially those of Gobi, which extend even to the confines of China and Thibet. Its stature is that of a mule of the common dimensions, its length being somewhat more than five feet, and its weight from 400 to 500 pounds. The head is large, with an appearance of heaviness, and the front flattened; the eyes are of moderate size, with ash-coloured irides; the mouth is furnished with thirty-four teeth; the neck is slender and compressed, with a soft erect mane, and, on the foretop, there is a tuft of downy hair about two inches in length; the body is rather long; the breast large and protuberant; the back somewhat concave and depressed, with the flanks and hinder part thin, as in the mule, to which animal its general conformation bears much resemblance; the limbs are long and slender, with an oval callus within the fore legs. The hoofs resemble those of the ass; and the tail, which is two feet in length, corresponds with that of the cow, in being naked for half its length, and having the tip hairy.

During summer the prevailing colour of the animal is yellowish brown, with the upper part of the head, and inner parts of the limbs, tawny; but the inside of the hind thighs and the belly are said to be sometimes whitish. The nose is white; the mane and tail are blackish; and the back is marked with a line of chesnut, or deep black, extending from the mane to the tail. The summer coat is much smoother than that which it assumes in winter; for the hair during the latter season is large, and it also changes to a deeper or more ruddy hue, inclining to grey at the tips.

The jictas are of a very social disposition among themselves, living together in troops of twenty or thirty, or sometimes of nearly a hundred. They haunt the open plains, which abound in salt marshes, and they never approach the forests or mountainous situations. Each of the troops is placed under the guidance of a leader, which is constantly on the watch while the others repose or feed, and which, in case of danger, gives the signal of alarm by leaping, and looking stedfastly at the object which excites its fears. This vigilant scout is often killed, because he is stationed at some distance from the herd, and often approaches still nearer the hunters, in order to watch them attentively. When he falls, the herd do not disperse till many of them are killed. When alarmed and put to flight, they dart along with the swiftness of the antelope. They have the senses of sight and smell in exquisite perfection. In their manners they are naturally timid; but, when closely pursued, are very fierce, and defend themselves both with their feet and teeth. Their neigh is shriller than that of the horse. The females go with young from August till the following spring, when each produces one, or rarely two young. The people of the deserts pursue them only for the sake of their flesh and skin, the former of which they esteem a delicacy. From the untractableness of their disposition, there seems to be little probability of rendering them essentially serviceable as beasts of draft or burthen.

* *E. asinus.* Although, in our own country, this species is far less common than the horse, it is still sufficiently known to render any particular description unnecessary. In many parts of Asia, in its native wilds, it is far superior, both in point of beauty and vivacity, to the dwindled and dejected appearance which it exhibits in our northern climates, and in habitual servitude. In its natural state, it chiefly occurs in the dry and mountainous deserts of Tartary, and in the southern parts of India and Persia. It is also said to be met with in Africa, and, though very rarely, in some parts of Syria and Arabia, where in ancient times it was very common. The wild ass stands higher on its limbs than individuals of the domesticated breed, and its legs are more slender in proportion. Its hair is very fine, light coloured, soft, and silky, and, on some parts, marked by a few obscure waves or undulations; but the native ass of India is feeble, small, bow-legged, and apt to be short-winded. Wild asses live in small herds, are timid and vigilant, being regularly conducted by a leader, and possessing the senses of smelling and hearing in an eminent degree. Their favorite food consists of the wild plants of the desert, and of bitter lactescent herbs. It is likewise worthy of remark, that they prefer brackish to fresh water.

The ass, like the horse, was imported by the Spaniards into America, where it has greatly multiplied, and even, in some cases, become troublesome from its numbers. When allowed to run wild, they have all the fleetness of horses, and neither declivities nor precipices can easily retard their career. When attacked, they defend themselves by means of their heels and mouth, and with such address, that, without slackening their pace, they often maim their pursuers. But, after being doomed to bear their first load, their swiftness seems to forsake them, and they soon contract the stupid looks and the dulness for which they are proverbial.

In Spain, the breed of asses has, by care and attention, been greatly improved, insomuch that in that country they are strong, elegant, and stately, and are often fifteen hands high. Egypt and Arabia likewise excel in large and handsome asses, which often fetch a higher price than the horses, and which, in their attitudes and movements, manifest a degree of noble gracefulness unknown even in those of Spain. With great sureness of foot they combine quickness, alacrity, and ease, in all their paces. Being more hardy than the horses, they are preferred to them for long journeys and pilgrimages across the deserts. In our own, and some other countries in modern Europe, a defect of good sense and humanity has doomed this unfortunate species to neglect, contempt, and oppression. Among its most able eulogists, we may cite the Count de Buffon and the Abbé de la Pluche.

To the peasants, these animals are much more desirable than horses, because they not only have greater proportionate strength of body, and are more sure footed, but also because they are infinitely more healthy, and kept at much less expense. So hardy, indeed, is their temperament, that, even in the depth of winter, the most wretched hovel will suffice to shelter them from the cold ; and such is their sobriety, that they can subsist on vegetables which most quadrupeds refuse to eat. The thistle and plantain, which generally grow in waste places, and along the sides of highways, afford them a welcome feast at the close of their daily toils.

When young, the ass is generally of an unhandsome appearance, and is, moreover, gay and frolicsome ; but age, harsh treatment, and excessive fatigue, frequently render him slow, dull, and headstrong. Yet he acquires a strong attachment to his master, whom he will often recognize in a crowd ; he is familiar with all the places where he has lived, and retains a distinct recollection of all the roads along which he has been accustomed to travel. When loaded beyond his strength, he expresses his uneasiness, by lowering his head, and bending down his ears. If greatly abused, he will open his mouth, and draw back his lips in a disagreeable manner. He is much afraid of wetting his feet, and will, even when loaded, turn aside to avoid the dirty parts of the road. He is also capable of being trained to perform many tricks and antics, various instances of which are recorded by Leo Africanus, Gesner, Pennant, &c.

The natural duration of the ass's life is from 25 to 30 years. Though capable of propagating at two years, it does not attain to perfect maturity till four. The term of gestation is nearly twelve months ; and the produce is usually one, though sometimes two.

The skin of the ass, from its hardness and elasticity, is capable of being converted to various uses, being manufactured into shoes, heads of drums, &c. and, when varnished over in a particular manner, it is cut into leaves for pocket-books. The inhabitants of some of the eastern countries make of that part of it which is near the rump what they call *sagri*, which we have corrupted into *shagreen*. In Tartary, the flesh of the wild ass is reckoned not inferior to that of the boar ; but that of the domestic variety is certainly hard, dry, and stringy. The milk is light, easy of digestion, and so salutary to delicate constitutions, that it is recommended as a specific in pulmonary complaints. In some parts of the continent, it is occasionally used as a cosmetic.

Although individual horses and asses frequently betray something like constitutional antipathies to one another, they nevertheless sexually intermingle, and give rise to the hybrid offspring, denominated *mule* and *hinny*, the former being the produce of the jack-ass and the mare, and the latter of the horse and the she-ass. The mule is considerably the larger of the two, assuming more the appearance and dimensions of the mare than of the ass. Its fore parts are better shaped ; the chest is broader and more elegant ; the rump fuller, the haunches are smoother, and the sides rounder. In the head, and the other extremities, it bears some resemblance to the male parent. The hinny, on the contrary, obviously partakes of the dimensions and appearance of the mother ass. Its chest, however, is thinner ; its back more ridged ; its rump sharper, and its head longer, and not so thick in proportion : whereas the head of the mule is both thicker and shorter than that of the mare. The tail of the hinny is covered with longish hairs, while that of the mule exhibits little else than short hair. The ears of the mule are longer than those of the horse, and those of the hinny are shorter than those of the ass. Of these two hybrid animals, the mule is by far the most generally cultivated, because it is much more robust and hardy, and every way more fitted for the purposes of riding, draft, and burthen. The mule is longer lived than either the horse or ass, less liable to disease, and more capable of vigorous exertion. These remarks, however, apply to such as are properly bred, and not to the degenerate few produced from diminutive parents in this country. In Spain, fifty or sixty guineas are no uncommon price for a good mule ; and people of the first rank rear or purchase such for carriages. The mule and hinny are incapable of propagating with one another ; and, although in hot countries, instances have occurred of their fertile union with the parent species, the offspring of such a connection remains for ever barren.

The mule has become a proverbial synonyme of *obstinate*, probably because it resists ill treatment with firmness, and is not easily compelled to deviate from the path which it marks out for itself. It is, however, extremely sure footed, and in most cases, the best judge of its own movements. "It is entertaining," says a facetious traveller, in describing a journey in the Alps, "to observe the prudence of these animals in making their way down such dangerous rocks. They sometimes put their heads over the edge of the precipice, and examine with anxious circumspection every possible way by which they can descend, and at length are sure to fix on that which, upon the whole, is the best. Having observed this in several instances, I laid my bridle on the neck of my mule, and allowed him to take his own way, without presuming to control him in the smallest degree.

"This is doubtless the best method, and what I recommend to all my friends in their journey through life, when they have mules for their companions."

* *E. zebra.* (Plate CCCLVIII. Fig. 46.) In size, this species equals, or rather surpasses the ass. The head and ears are well shaped, and of moderate dimensions ; the ground colour is either milk or cream white, with a very slight dash of buff, or pale ferruginous ; and the numerous stripes, which are disposed with the nicest symmetry, are either black, or blackish brown, running in a transverse direction both on the body and limbs, and in a longitudinal one down the face, while their regular and elegant gradations and flexures cannot be viewed without admiration. The tail is of moderate length, round, rather slender, marked with small blackish bars, and terminated by a thickish tuft of brown or black hairs.

Large herds of zebras assemble in the day-time in the extensive plains of interior Africa, and, by their liveliness and beauty, cheer and adorn the dreariness of the surrounding scenery. They abound in some of the districts not far from the Cape of Good Hope ; but hitherto they have not been successfully trained either to the saddle or the yoke. Le Vaillant compares their cry to the whizzing sound of a stone projected along a surface of ice. According to the same writer, their alleged untameable disposition is a mere prejudice of learned naturalists, since savage Africans consider them as a fit substitute for the horse. If caught young, and reared with kindness, we have little doubt that they might be rendered subservient to domestic purposes. As the Hottentots hunt the zebra merely for the sake of the flesh, it is no wonder that it should regard man rather as its foe than its protector; and when it happens to be taken alive, it is not surprising that it should be perverse and mischievous, or that it should refuse obedience to that being from whom it has so seldom experienced mercy.

Several individuals of this species have, at different times, been exhibited in England, one of which, a female, was decoyed into union with a jack-ass, painted like a male zebra, and not only conceived, but produced a fine large foal.

III. Nectopoda, or Mammalia with swimming Paws.

Order X. AMPHIBIOUS.

The four feet apparent; no spiracles; a pelvis; grinders, and often tusks; cutting teeth sometimes wanting; clavicular bones; body usually covered with hair; a small cæcum; bone in the penis. Resident both on the land and in the water.

1. Genus Phoca, Lin. &c. Six upper cutting teeth, four lower, and equal; tusks long, strong, and pointed; grinders with a lobed and sharp crown; hind feet placed at the extremity of the body, in the same direction with it, and serving the purpose of a caudal fin; fore feet also adapted to swimming, and furnished with five claws; a very short tail between the hind feet; external ears either small or wanting. Resident chiefly on sea coasts, especially in the northern countries.

This is properly a marine family, though one or two of the species may also be met with in fresh water; and all are so constituted, as to require occasional intervals of repose on the land, rocks, or floating ice, forsaking the water at particular periods in great crowds, and assembling on the shores, or penetrating into cavernous recesses, especially during the breeding season. In most of the species, the *foramen ovale* is supposed to remain open, which enables them to suspend their respiration for a considerable time together. Still, however, they are obliged at intervals to thrust their noses above the surface of the water, in order to reject the vitiated air of their lungs, and take in a fresh supply. Of the fore legs, which outwardly appear to be very short, the parts called by anatomists *brachium* and *antebrachium*, are concealed under the skin of the breast, the wrist being the first joint on the outside. Of the hinder extremities, in like manner, neither the thighs nor legs are visible. Owing to this singular structure of limbs, seals crawl on land with awkwardness and apparent difficulty, but move easily and gracefully in their proper element. By means of their fore feet, they can lay hold on objects with sufficient firmness to drag themselves up shores, and even over shoals of ice, however slippery they may be. They are observed, indeed, to move with more quickness than, from their general form and appearance, might be expected, insomuch that, though dangerously wounded, the hunters are frequently unable to overtake them before they get to the water's edge, and precipitate themselves beyond their reach. There are no large medullary cavities even in their long bones. The crystalline humour of their eyes is nearly as spherical as that of the same organs in fish. These animals do not attain to their full growth for several years; and Buffon is inclined to believe that the duration of their lives often extends beyond a century. It is a prevalent opinion that they never go beyond soundings, or far from the shore; but those which Captain Cook's people encountered in the South Seas prove the contrary.

The females produce two or three young, generally in the winter season; continue to feed them, for twelve or fifteen days, in the place where they were first brought forth; and suckle them nearly in an upright position, resting on their hind legs. When the cubs have acquired sufficient strength to contend with the waves, the mother conducts them into the water, and teaches them to swim about and seek for food. The attachment of seals of the same species to one another, and especially to their own offspring, is highly interesting. Though they appear to be much more partial to cold than to warm climates, yet some of them are found in almost every sea, living on fish and other marine animals. Though bold, dirty, and quarrelsome, they are very capable of being tamed. Buffon properly remarks, that some of the species are furnished with external ears, whilst others have only small auditory orifices; and, from this distinction, he deduces a natural subdivision; but he has incautiously limited the presence of external ears to the *Ursina* and *Jubata*, whereas it likewise characterizes the *Chilensis*, *Falklandica*, *Porcina*, and *Flavescens*.

* 1. *P. leonina*, Lin. *Bottle-nosed Seal*, or *Sea-Lion*. Body cinereous brown, head of the male crested on the fore-part. 2. *P. cristata*, Lin. *Crested Seal.* Grey, with a folding skinny crest on the forehead. 3. * *P. ursina*, Lin. *Ursine Seal*, or *Sea Bear.* Eared, nose flattish, fore feet shaped like fins. 4. **P. jubata*, Lin. *Maned*, or *Leonine Seal*, or *Sea Lion.* Reddish-brown, with a large mane round the neck of the male. 5. *P. barbata*, Lin. *Great Seal.* No external ears; head smooth; body blackish above, white beneath. 6. * *P. vitulina*, Lin. *Common Seal*, *Sea Calf*, or *Sea Dog.* Head earless, neck smooth, body dark coloured. 7. *P. Groenlandica*, Lin. *Harp Seal.* Head smooth, and earless; body grey, with a black dorsal crescent, of which the horns point downwards, along the sides. 8. *P. hispida*, Lin. *Rough Seal.* Sub-auriculated; head smooth; body pale brown, and covered with rising bristly hair. 9. *P. pusilla*, Lin. *Little Seal.* Sub-auriculated; body dusky; head smooth. 10. *P. lupina*, *Urigne Seal.* Earless; head like that of a dog; fore feet fin-shaped. 11. *P. bicolor*, Lin. *Pied Seal.* Without external ears; brown, variegated with white, nose lengthened; membrane of the hind feet expanded in form of a crescent. 12. *P. monachus*, Lin. *Hooded*, or *Mediterranean Seal.* Earless, with four cutting teeth in each jaw, fore feet undivided, the hind fin-shaped and clawless. 13. *P. longicollis*, Lin. *Long-necked Seal.* Without external ears; long-necked, fore feet fin-shaped. 14. *P. Falklandica*, Lin. *Falkland Isle Seal.* Cinereous, with small pointed ears, and furrowed cutting-teeth. 15. *P. testudinea*, Lin. *Tortoise-headed Seal.* Head shaped like that of a tortoise, neck slender. 16. *P. fasciata*, Lin. *Ribbed Seal.* Blackish, with a squarish dorsal-yellow band. 17. *P. leporina*, Lin. *Leporine Seal.* Fur white, soft, and somewhat erect. 18. *P. porcina*, Lin. *Porcine Seal.* Eared, with hog-like snout, and five-toed feet. 19. *P. flavescens*,

Lin. *Yellowish Seal.* Yellowish, with pointed ears. 20 *P. Chilensis*, Lin. *Chili Seal.* Ears somewhat long; five toes on each foot.

* *P. leonina.* When fully grown, this animal measures from eleven to eighteen feet in length, and from seven to eleven in circumference. The skin, which is an inch thick, is covered with a very short, shaggy, and glossy hair, of a cinereous hue, and sometimes slightly tinged with olive. The blubber under the skin is a foot in thickness, and yields about five hundred pints of oil. The quantity of blood in each individual is also very considerable, and will sometimes fill two hogsheads. The male is at once distinguished by a singular appendage, or projecting snout, which hangs several inches over the lower jaw, and the upper part of which consists of a loose wrinkled skin, like a cock's comb, which, when the animal is irritated, is capable of inflation, so as to give the nose an arched or hooked appearance. The whiskers are white, and ringed with red.

The bottle-nosed seals abound about the Straits of Magellan, Juan Fernandez, and the Falkland Islands; and as Steller likewise saw them at Bhering's Island, and on the coast of Kamtschatka, we may presume that they equally inhabit both hemispheres, and may probably be found in all latitudes. Their manners and habits nearly correspond with those of the *ursina;* but they pass the summer in the sea, and the winter on the land. When on land, they live on such plants as grow on the sides of running waters; and, when not occupied in feeding, they usually sleep in the mud, and are not easily roused from their profound slumbers. They have the precaution, however, to station male centinels round their haunts, to awaken them on the approach of danger. Their cries are noisy and discordant, sometimes resembling the grunting of hogs, and sometimes the neighing of horses. The males frequently contend for the females, and bite one another very severely. The dams bring two, and sometimes three, at a litter. Lord Anson's people killed many of this species in the Isle of Juan Fernandez for food, and called their flesh *beef*, to distinguish it from that of the common seal, which they termed *lamb*. The epithet *leonina*, however, and the expression *sea-lion*, adopted by the elegant editor of Anson's Voyage, are particularly unfortunate appellations, because they tend to confound the present species with the *jubata*.

* *P. Ursina.* Measures from six to nine feet in length, and weighs about 800 pounds. This species is very generally diffused over the world. In the seas of Kamtschatka, and about the uninhabited islands situated between Asia and America, it occurs in great multitudes. Steller, who had ample leisure to contemplate their structure and history, informs us, that they migrate from these inhospitable shores in the month of June, and return about the latter end of August, or beginning of September, in a reduced and emaciated state. On dissecting some of them at this period, the stomach and intestines were found to be empty; whence it has been conjectured, that, during the breeding season, which occurs in their absence, they take little or no food.

The ursine seals are covered with long, thick, and bristly hair, which is black on most of the body, but yellowish or rufous on the sides and feet. Under this is a sort of *felt*, or fine hair, which is short and very soft. During the greatest part of the year, they are furnished with a layer of fat about four inches thick, and of a disagreeable taste. The nose resembles that of a pug-dog; the nostrils are oval; the lips thick, and serrated within; the whiskers long and white, and the teeth lock into one another when the mouth is closed. The eyes, which are large, prominent, and black, with an emerald-green pupil, are provided with a fleshy or nictitating membrane, by which they may be occasionally fenced and covered. The tail is only two inches long.

The history of these seals, as detailed by Steller, Kracheninnikow, Pennant, and others, is by no means destitute of interest. While thousands of them may be observed on their favourite shores, they associate in families, and keep their respective boundaries or stations. Each family consists of one male, and usually eight or ten, but sometimes fifteen, twenty, or more females, with their young offspring. The male, for the most part, conducts his own family, preserving it distinct from conterminous tribes. Hostilities, however, occasionally originate in rival jealousies, and the vanquished horde is annexed to that of the conqueror. When only two chiefs are engaged in the combat, they pause at intervals, laying down near each other, and then, starting up simultaneously, renew the battle, fighting with their heads erect, and turning them aside to shun the blows. While their strength continues nearly equal, they make use only of their fore paws; but the moment that one of them begins to relax in the strife, his adversary seizes him with his teeth, and throws him on the ground. So deep are the mutual wounds of these creatures, that they might be mistaken for the cuts of a sabre; but the animals are very tenacious of life, and have been known to survive wounds which would have instantly proved fatal to most quadrupeds. The old ones are so intent on guarding their own limits, that they snap at every invader, and give him battle. In the course of the contention, they insensibly impinge on the confines of their neighbour, who instantly joins in the conflict, till at length the discord rages along the whole shore, and is proclaimed by hideous growlings. In proportion to the violence of these deadly feuds, seems to be the warmth of attachment that subsists between the members of the same family. The old males, which lead a solitary life, are observed to be more peevish and quarrelsome than the others, and shun not the approach of man. The females, on the other hand, in the moment of danger, are chiefly occupied in protecting their young, and, though wounded, will frequently carry them off to sea in their mouths.

When these seals come out of the water, they shake themselves, lie down to bask in the sun, and wag their hind legs as a dog does his tail. Sometimes they lie on their back, and sometimes roll themselves up into a ball, and fall asleep. Their cubs are lively and sportive, and, in their sham fights tumble one another to the ground, while the male parent eyes them with complacency, and expresses his approbation by licking and kissing them. It has, moreover, been remarked, that the ursine seals modify their cries according to the circumstances or passions which predominate. In a state of repose on land, the females and their young utter a noise which has been compared to the distant bleating of sheep and calves; when they suffer pain or weariness, they bellow; and when they have been assailed by blows, or conquered in battle, they blend their groans with a lugubrious hissing, like that of the sea-otter; in their combats they roar like the lion; and joy or victory they express by a shrill call, frequently repeated. Their external senses, especially that of smell, are said to be very acute; nor is their progressive motion by any means so sluggish as the conformation of the feet would seem to indicate; for they crawl along nearly as fast as a man can run; and they often swim at the rate of seven or eight miles an hour. In their gambols near the shore, they toss and tumble about, sometimes swimming on their back, and sometimes on their belly; or they will remain for a little in a vertical position, or dart from the water to the height of several feet.

The females of this species go about ten months with young, and produce one, or rarely two, in the month of June, on the deserted islands of the northern hemisphere. They give suck till the end of August. The flesh of the young is reported to savour of lamb and sucking pig; but that of the adults is black, and extremely disgusting to palates of any delicacy.

On Bhering's Island these creatures were found in such numbers as to cover the whole shore; so that travellers, for their own safety, were obliged to leave the sands and level country, and go over the hills and rocky parts.

* *P. jubata.* (Plate CCCLVIII. Fig. 47.) This is the largest of the eared seals, being from ten to fourteen feet in length, and weighing 1500 or 1600 pounds. Still greater dimensions have been ascribed to such of them as frequent the Falkland Islands, namely, twenty-five feet in length, and nineteen or twenty feet round the shoulders. The diameter is nearly equal throughout, thus differing from the general form of the family. The females are considerably shorter, and more slender than the males, seldom exceeding seven or eight feet in length. The upper lip projects over the under, and both are furnished with five rows of whiskers like bristles, or rather quills, sufficiently strong to be used as tooth-picks; the ears are conical, and only six or seven lines long; the eyes are large, prominent, furnished with a nictitating membrane, with the pupil of a fine emerald green, and the greater angle as if stained with cinnabar. The male differs from every other marine animal by its mane of thick, waving, and fulvous hair, about three inches long, which covers the fore-head, cheeks, neck, and breast, and is erected when the animal is irritated.

This species inhabits the shores of the Magellanic Straits, the Penguin, Seal, Falkland, and Kurile Islands, the coast of Kamtschatka, &c. In June, July, August, and September, they abound in Bhering's Island, to which they resort for the sake of quiet parturition and suckling their young. Like the preceding species, they are polygamous, each family consisting of a full-grown male, ten or twelve females, and fifteen or twenty young. These keep apart from those of the ursine or bottle-nosed tribes, which they seem little inclined to attack; and, unless rendered desperate by wounds, they retreat from man. The seal-hunters prefer taking them by surprize on land, to harpooning them in the water, as, when galled with wounds, they frequently overturn the boat. The Kamtschatkadales pursue them more from ideas of honour and glory, than from any benefit that can accrue from the spoil. In the chase of a single sea-lion, these savages will expose themselves to the greatest dangers, wandering over the waves for days together, without any other guide than precarious glimpses of the sun and moon; and he who kills the greatest number, either by the blows of a long stick, or by poisoned arrows, is regarded as the most heroic. As the adventurous sportsmen deem it ignoble to leave any of their game behind them, they sometimes overload their limber and crazy boats, and, scorning to save their lives by the rejection of any portion of their highly prized acquisitions, proudly perish with them in the waves.

Mr. Steller assures us, that, in consequence of gentle treatment, sea-lions may be rendered so tame as to divest themselves of all reserve in the company of human beings. He once lived for six days in a hovel, pitched in the middle of their rendezvous, and found that they were soon perfectly reconciled to his presence. With great calmness they would observe all his proceedings, lie down opposite to him, and suffer him to seize on their young. His situation enabled him to witness the combats among their males, particularly one which was sustained between two individuals during three days, in which one of the parties received no fewer than a hundred wounds. The ursine seals never interfered, but got out of the way as fast as possible. During the months of June and July, the old males abstain almost entirely from food, occasionally swallowing pebbles, to keep the stomach distended, resign themselves to sleep and indolence, and become extremely emaciated. The females go ten months with young, and produce only one at a birth. The cubs are not sportive like most other young animals, but sluggish and drowsy. In foggy weather, the lowing and bleating cries of these animals have often rescued the mariner from impending shipwreck.

The flesh of the young is not unsavoury; and the feet may be converted into jelly; the fat is compared to the suet of mutton; and the skin is manufactured into straps, shoes, boots, &c.

P. Vitulina. Length from four to six feet; the forehead nearly resembling that of the otter. On each side of the mouth are whiskers, which are either black, or black and white, and beyond them, and near the anterior corner of the eye, are others, which are flat and knotty. The hind part of the head is very large, the neck short, the breast larger than the belly, and the tail very short and flat. The hair of the whole body is short, laid backward, dry, stiff, and glossy, usually brown, or blackish, with the tips of a yellowish-grey. The colour is, however, subject to considerable variety, being sometimes silvery, sometimes spotted with white, or yellowish, and, according to some writers, even reddish. At the roots of the hair, there is a fine and close down. The stomach, which is situated in the middle of the epigastric region, is bent like the segment of a circle, and is very long in proportion to its breadth. The cæcum is very short, and rounded at the end; the heart long and flabby; and the lungs, liver, and gall-bladder, are all very large. On the common assumption, that the quantity of brain determines that of the understanding, the seal would, of all animals, man not excepted, be the most sagacious; for it has, in proportion, the largest brain of any.

This species, which admits of several varieties, inhabits not only the Baltic, but the whole range of ocean from Greenland to the Canary Islands, or the Cape of Good Hope, the Mediterranean, the Black and Caspian Seas, and even the lakes of Baikal, Orom, Ladoga, and Onega. In fresh water lakes, however, it is of a small size, but so fat as to appear almost shapeless. It has also been observed in the higher latitudes of the southern hemisphere. Its appearance is quite familiar on the northern, western, and rocky shores of Scotland. It seldom removes to a greater distance than twenty or thirty leagues from land, affects caverns and hollow rocks, and, during the hot days of summer, frequently leaves the water, to sleep, or bask in the sun.

The state of watchful precaution which the common seals observe, when they sleep on the rocks or sandbanks, within the reach of people on the coast, is, doubtless, prompted by experience, which teaches them to post a sentinel that may give the first alarm of danger, and to raise their heads at frequent intervals; for, in situations in which they are most rarely disturbed, their sleep is uncommonly profound, and they are easily surprised. When collected in multitudes, their fetid odour is sometimes perceived at a considerable distance. Like others of their genus, they are provided with a large quantity of blood and fat. The voice of the full grown animal resembles the hoarse barking of a dog, and that of the young has been aptly compared to the mewing of a cat or kitten. The old ones bark at those persons who attack them, and make every effort to bite their assailants. It has also been remarked, that they seem to gaze with pleasure on flames, to be delighted with a thunder storm, and the consequent rain, and to be fond of gingling and musical sounds. Late in autumn, or early in winter, the female produces her young, which seldom exceed two, and which are white and woolly. These they deposit in the cavities of rocks, or ice, suckle for two or three weeks on the spot where they are born, and then take out to sea, to instruct them in searching for their food, which consists not only of fish, testaceous, and crustaceous animals, but of some varieties of sea-weed. When they happen to encounter a shoal of herrings, they destroy them by thousands; but they are often obliged to hunt after fish that are much stronger, and more capable of evading their pursuit. On several parts of our own coast, they are particularly injurious to the salmon fishery. They are, for the most part, easily killed by a blow on the head, but, in other respects, they are very tenacious of the vital principle. They are expert swimmers and divers, and sport about ships with great playfulness.

The hunting of seals is prosecuted with great eagerness, in various modes, and often with much personal danger, by the Greenlanders, Finlanders, &c. In the Caspian Sea it is conducted on a very profitable scale by the more opulent merchants of Astrachan. It is almost superfluous to observe, that the fur, hide, and oil of the common seal form so many articles of commerce, and that even the flesh is held in considerable estimation, as it appears to have been in our own island in former times.

Various instances are recorded of seals having been tamed, and of their betraying a marked attachment to those who have the care of them.

2. Genus Trichecus. Two small cutting teeth, and two very large tusks, bent downwards, in the upper jaw; neither tusks nor cutting-teeth in the lower; grinders flat, having an elevated and transverse line in their middle; body less elongated than that of the seals; no external ears. Resident on the shores of the northern seas.

* 1. *T. rosmarus*, Lin. &c. *Arctic walrus*, *Morse*, *Sea-cow*, &c. (Plate CCCLVIII. Fig. 48.) The whiskers, which proceed from spongy flesh on the sides of the mouth and nostrils, are thick hairs, resembling pellucid straws, three inches long, and slightly pointed at their extremities; the mouth is uncommonly small, the lips are very thick, the nostrils lunated, the eyes small, red, fiery, seated deep in their sockets, and retractile from external injuries. The whole animal is of a lumpish inelegant form, with a small head, thick body, and very short legs; the skin is generally about an inch thick, more or less wrinkled, especially about the joints, and scattered over with short brownish hair; the hind are considerably shorter than the fore feet; and the tail is extremely short. The two large tusks are formed of ivory of a granulated texture, with the central part brownish, usually measure about a foot in length, four inches in breadth at the base, and, jointly, weigh from eight to fifteen, or even twenty pounds. With these formidable instruments the walrus scrapes shell-fish, and other prey, out from the rocks, sand, &c. climbs masses of ice by fixing them in the fissures, and defends itself against the white bear, the sword-fish, shark, and other adversaries. The length of the animal is from fifteen to eighteen feet; the circumference, in the thickest part, nearly as much, the weight from 1500 to 2000 pounds; and the white and firm blubber, which invests the flesh, to the thickness of three inches, seldom yields less than half a ton of oil.

These animals are gregarious, and, in their habits, resemble the seals, with which they readily consort; but they are not observed to advance further south than between the 47th and 48th degrees of north latitude, their chief haunts being the northern coasts of America, Greenland, Spitzbergen, Nova Zembla, and the headlands that stretch towards the arctic pole. In 1608, they were found on Cherry Isle, a solitary spot between Norway and Spitzbergen, huddled on one another, and in such multitudes, that a ship's crew killed above 900 in the short space of seven hours. Herds, consisting of several hundreds, are frequently seen on the floating ice; and thousands have been driven, by the persecution of man, into the most sequestered and inaccessible retreats. According to Zordragger, before they were regularly hunted, they would venture a considerable way into bays and inlets, so as to be easily captured at low ebb tides. Some of the ship's crew marched directly against the herd, to cut off their retreat from the water; and the devoted victims waited the hostile approach without apprehension or suspicion. The slaughter was easy and inglorious; a barrier was formed of the carcasses; a party of hunters was dispatched to attack the stragglers, and three or four hundred were sometimes killed at one landing. When wounded, they become furious, and deal heavy blows around them with their tusks, breaking the weapons of their assailants, or wresting them from their hands, and rolling into the water with their head between their paws. When collected in numerous bodies, they act in concert for the destruction of the common enemy, surrounding the boats, and endeavouring to pierce them with their tusks, or to upset them, by beating forcibly against their sides, roaring, at the same time, in a dreadful manner, and gnashing their teeth with great violence.

The female produces in winter, or spring, and on the ice or land, usually a single cub, about the size of a pig of a year old. "She will defend the young one," says Captain Cook, "to the very last, and at the expense of her own life, whether in the water or upon the ice. Nor will the young one quit the dam though she be dead; so that if you kill one, you are sure of the other. The dam, when in the water, holds the young one between her fore fins." The walruses frequently come on shore, are much addicted to sleep, and snore very loud. They discharge the water from their nostrils, as the whale does from its spiracles; and, when closely pursued, they are observed to disgorge the contents of their stomach, among which are small stones. When unmolested, they are harmless; but the concurrent testimony of voyagers sufficiently proves, that their numbers have been thinned, and their former sense of security destroyed, by the unequal war which they were compelled to wage with the human race. They are also involved in frequent and fierce contentions with the polar bear, probably for the occupancy of the same piece of ice. In these conflicts the walrus, from the advantage of its enormous teeth, usually proves victorious. When the Greenlanders observe a herd of them on the ice, they approach them in their boats, and throw their harpoons as the animals are tumbling along the steeps into the sea. They prefer these opportunities, because the walruses distend their skins, to roll with greater ease and lightness, and are, consequently, more easily struck than when at rest on shore, with the skin flaccid.

Sir Robert Sibbald, in his *Prodromus Historiæ Naturalis Scotiæ*, enumerates the walrus among our marine animals, though apparently on the authority of Boethius. That it formerly inhabited the Norwegian seas cannot be doubted; and, in course, it may have been occasionally observed on the Scottish coasts; but we cannot vouch for the fact on the doubtful testimony of Boethius. Neither can we precisely ascertain the import of the *ελεφαντινα ψαλια*, or *ivory bits*, which Strabo mentions among the articles of British commerce, and which might be formed of the narwhal's tusk, or the teeth of some of the cetaceous families.

Authors differ considerably respecting the quality of the ivory obtained from this species, some representing it as inferior to that of the elephant, and more apt to turn yellow, whilst others contend for its greater compactness and whiteness. The fact seems to be, that the tusk of the walrus is not equally sound throughout, and, consequently, is not much in demand among the ivory workers. The animal, indeed, is now killed chiefly for the sake of its oil. It is proper, however, to note, that an excellent elastic leather, particularly fitted for harnessing, may be prepared from the skin, which is also used in the manufacture of English glue. Of the same material the old Normans made their almost imperishable cables. Superstitious seamen make rings of the whiskers, and use them as preservatives against the cramp.

The history of the arctic walrus, which we have thus very briefly sketched, suggests three obvious reflections. 1. It furnishes us with one among many instances, which seem to prove, that fear and distrust of the human race are not originally inherent in the brute creation; but the result of experience, which teaches the inferior animals to avoid all those beings whose superior strength or skill has been felt injurious to their existence. 2. That the all-wise and bountiful Creator, when he destined this animal to reside in the northern regions, provided it with a thick cover of fat, to protect it from the inclemency of the climate. 3. That in an apparently shapeless mass of matter, and under the prolonged rigours of the polar winter, the warmth of the vital principle, and the charms of parental and filial affection, are found to have a place even beyond the sphere of human intercourse, and to soothe and enliven, with their moving and tender interests, the dreary abodes of frost and tempest.

3. Genus DUGONG, La Cép. *Trichecus*, Lin. Neither cutting teeth nor tusks in the lower jaw, two straight and short tusks in the upper, four grinders in the upper, and three on each side in the lower jaw, with a concave crown. Resident in the Indian seas.

* 1. *D. Indicus*, La Cép. *Trichecus dugong*, Lin *Dugong*, or *Indian walrus*. This large animal, which was called, without any obvious analogy, *Sea-cow*, by the early Dutch voyagers, has its head covered with a kind of shaggy hair, and has a strong general resemblance to the *Manati* of the West Indies, from which, however, it is perfectly distinct. It inhabits the sea between the Cape of Good Hope and the Philippine islands, the coast of Sumatra, &c. The tusks afford ivory of a superior whiteness, and which is manufactured into handles of knives and Indian daggers.

4. Genus MANATUS, Cuv. and La Cép. TRICHECUS, Lin. Numerous grinding teeth, with two or three transverse ridges on the crown; no cutting teeth, or tusks; head small and rounded, as in the seals; nostrils placed high; auditory orifices scarcely visible; fore feet much resembling those of the seals; the hind placed at the extremity of the body, included in a common membrane connected with the tail, properly so called, and thus forming a sort of caudal fin; stomach divided into several lobes.

* 1. *M. borealis*, *Trichecus borealis*, Lin. *Whale-tailed trichecus*, or *manati*. Hairless, with a horizontal tail; skin brown when wet, but black when dry. 2. *M. australis*. *Trichecus australis*, Lin. *Round-tailed*, or *Guiana trichecus*, or *manati*. Fore-feet with five toes, and clawed. * 3. *M. siren*, *Trichecus siren*, Lin. *Siren trichecus*, or *Sea-ape manati*. Ears erect, and sharp pointed.

* *M. borealis*. As the fore feet are fitted only for swimming, this animal never goes on shore, the female even bringing forth and suckling her young in the water. A full grown individual of the species measures from twenty to twenty-eight feet in length; twelve feet in circumference under the shoulders; twenty round the belly; and between four and five near the tail; which last is horizontal and crescent-shaped; the weight sometimes amounting to 8000 lbs. The head, in proportion to the mass of the body, is small and oblong; and the eyes are not larger than those of a sheep. The width of the auditory orifices exceeds not that of a goose's quill; the gape, also, is small; and the lips are double. Near the junction of the jaws, the mouth is beset with white tubular bristles, which, like the laminæ in some of the whale tribe, prevent the food from being discharged with the water. The lips and nostrils are also furnished with bristles. The tongue is small and pointed; the neck is uncommonly thick, and scarcely to be distinguished from the head; the skin is very thick, black, full of asperities, and invests the whole body like a hard crust; thus affording a protection against the ice and angular projections of rocks. The blubber, which is several inches thick, is said to taste like oil of almonds; and, when exposed to the sun, assumes the yellow hue of butter, for which it is no despicable substitute, especially as it retains its sweetness through the summer. The milk is thick and sweet; but the flesh is coarser than beef, and requires long boiling to render it eatable. That of the young tastes like veal. The skin is principally used for shoes, and for covering the sides of boats.

According to Steller, who not only described, but dissected several individuals of this species, they chiefly affect sandy and shallow shores, and the mouths of rivers, in the eastern seas, beyond Kamtschatka, and especially the neighbourhood of the desert island of Bhering. There they are very numerous, and so gentle and unsuspecting, that they suffer themselves to be handled, and take no precaution for their safety, till a blow or a wound makes them swim out to sea. The male seems to be strictly faithful to his mate ; and both are usually seen together, with a half-grown and a very small one. These families live very near to one another, the females compelling the young ones to swim before them, while the old ones surround and protect them. Not only are the members of the same family attached to one another, but the families of the same herd seem to be held together by a common bond of affection ; for, when one is struck with the harpoon, its companions swim to its assistance, some attempting to overturn the boat by getting under it, others pressing down the rope to which the harpoon is fastened, and others striking at the instrument itself with their tail, in order to extract it—an operation in which they frequently succeed. "I have observed," says Steller, "the mutual attachment of these animals, especially of the male to his mate. When we had harpooned a female, the male followed her, in proportion as we dragged her toward the shore, in defiance of the blows with which, in every direction, he was assailed. He did not even forsake her after she was dead ; for, on the following morning, when the sailors went to cut in pieces the female which they had killed the evening before, they still found the male waiting by her, on the water's edge."

With their lips, which are very hard, these creatures cut the stems and roots of the larger fuci, on which they feed with great avidity, plunging their head into water, that they may take hold of sea-weeds, and raising it again only for the purpose of respiration, so that, when eating, the fore part of their body is immersed in the water, while the half of their sides, and all their hinder parts, are above it.

* *M. siren.* The length of this species is about five feet ; the head somewhat resembling that of a dog ; the eyes are large ; the lips whiskered ; the body is thick, round, tapering downwards ; and the tail is divided into two unequal portions. The sea-ape manati inhabits the north-western coasts of America. Steller, who watched the movements of one of them, reports, that it was very frolicsome, swimming near the vessel, but suddenly retiring on the least alarm. It would often gaze at the ship with seeming admiration, stand erect with one-third of its body above water, then dart under the keel and appear on the other side, repeating this playful exercise about thirty times in succession. It would frequently rise with a sea-plant, resembling the bottle-gourd, toss it up, catch it in its mouth, and play with it numberless fantastic tricks. Let us suppose, for a moment, a group of this species amusing themselves with some of the narrow-leaved fuci, ulvæ, or confervæ, especially at some distance from the spectator, or seen through a hazy atmosphere, and we can easily fancy them transformed, by imagination, into *mermaids* and *mermen*, or *sea-nuns* and *bishops*, with long green or brown hair, and terminating in fishes' tails. The existence of marine animals, having their upper parts formed on the model of the human body, may, certainly, lie within the compass of Nature's boundless varieties : but the fact would require to be established on the most unquestioned evidence. Without the most remote intention, therefore, of insinuating any thing like disrespect of a few recent testimonies which have appeared in the public prints, we may be permitted to indulge a reasonable degree of scepticism, and to presume, that the reporters were deceived by the appearance of sea-apes, especially as the breasts of the female much resemble those of a woman, and have been particularly compared to those of a negress. Other accounts of a similar description, which the writer of this article has been at the pains to trace to their source, originated in the fashionable, but despicable spirit of *hoaxing*, which is but a gentler term for deliberate imposition. In regard to the older statements again, relative to mermaids, they are obviously too absurd to demand our serious consideration. Thus, several writers gravely relate, that, in 1430, after a violent tempest, which had broken down the dykes in Holland, some milk-maids of Edam found a mermaid left in the mud. They took her into their boat, washed her clean and brought her to Edam, where they dressed her in women's apparel, taught her to spin, and fed her as a human being. Some time afterwards, she was sent to Haerlem for her education, in which her proficiency was not particularly rapid ; for she would never deign to speak, and seemed always intent on returning to the water. Her pious instructors, however, would not allow her to revisit her native element, till she could make the sign of the cross, and courtesy to a crucifix. (H. N. A.)

MAN.

The sphere of human knowledge, which, in the nonage of society, is contracted and obscure, is destined, in the progress of civilization, to acquire definition, expansion, and magnitude. Facts, observations, and the results of important trains of reasoning, accumulate in the lapse of ages, and at length defy the most protracted term of human existence, and the most powerful efforts of intellect, to reduce them to general principles, or to exhibit them in a regular and systematic series. Nay, even on the supposition that such extended and complicated schemes lay within the reach of some individual pre-eminently endued with talents and capacities of combination, the very review of his labours would occupy a portion of leisure and attention greatly exceeding that which mankind in general are permitted to command. Yet is not the temple of knowledge suffered to fall in pieces from its own unweildiness, or to crush its votaries in the ruin of its altars. In consequence of a wise and beautiful provision, the exigencies of social inquiries are duly regulated and adjusted ; new divisions and subdivisions of study are instituted ; names and limits are assigned to them ; and, while the opportunities or the predilections of individuals determine to each his appropriate line of investigation, greater degrees of accuracy and facility of research are acquired, and the centres of discovery are propagated and multiplied. Thus matter and spirit become distinct departments of science, and thus the details even of the external world are ramified into classes and divisions. If, from the consideration of the earth itself, we pass to that of its inhabitants, it will at once be manifest, that the wonderful structure and organization of man belong to ANATOMY ; the derangements to which that structure and organization are liable, to MEDICINE ; and his principles of taste and reason, his appetites and passions, the nature and record of his social institutions, and the sentiments connected with his state of constant dependence on the Supreme Being, respectively, to CRITICISM, LOGIC, ETHICS, HISTORY, POLITICS, LAW, and THEOLOGY. More, it is presumed, need not to be said, in order to explain satisfactorily the seeming brevity of the present article, which has merely a reference to some of the leading physical facts in the natural history of our species.

In every known portion of the world in which man occurs, notwithstanding the diversities of his aspect and dispositions, he comes into the world the same naked being; he is furnished with two hands and two feet; walks erect; becomes capable of exercising the reasoning faculty and the powers of imagination to a far higher degree than any of the inferior animals; is susceptible of progress in social culture; enjoys the invaluable privilege of articulate speech; transmits his acquired knowledge to his descendants, and cherishes notions, more or less refined, of power infinitely superior to his own, and of a state of future existence. His organic conformation is closely assimilated to that of mammiferous animals; for his heart is furnished with two auricles and two ventricles; he has warm blood, and his female is viviparous, and suckles her offspring. Most of the ensuing particulars are also enumerated by Linné. The body, which seldom attains to six feet in height, is erect, and almost naked, having only some scattered, distant hairs, except on a few detached spots. The head is ovate; the scalp long, and covered with hair; the forehead broad; top of the head flat, and hind head protuberant. The face is naked, having the brow or forehead flattened and quadrangular; the temples are compressed, with peaked angles pointing upwards and backwards towards the scalp. The eyebrows are prominent, and covered with hairs, which, shedding outwards, cover one another, like tiles on a roof; and, between the inner extremities of the two eye-brows, there is a smooth shallow furrow, or depression, in a line with the nose. The upper eye-lid is moveable, but the lower nearly immoveable; and both are planted, at their edges, with a row of stiff recurved hairs, termed *eye-lashes.* The eye-balls are round, having no suspending muscles, as in those of most quadrupeds; the pupil, or opening of the sight, is circular, and the eye has no nictitating or winking membrane. The upper part of the cheeks are prominent, softish, and covered with a red blush, their outer parts flattened, the lower parts hollowed, lax, and expansile. The nose is prominent, and compressed at the sides; its extremity, or point, is higher than the rest, and blunt; the nostrils are oval, open downwards, with thickened edges, and hairy on their insides. The upper lip is almost perpendicular, and is furrowed on the middle, from the division between the nostrils to the edge of the lip; the under lip is erect, thicker, and more prominent than the upper, and both have a smooth red protuberance surrounding their mouth at their edges. The chin is prominent, blunt, and gibbous. In males, the face is round, and the mouth is ultimately covered with hair called the *beard.* The teeth in both jaws may be distinguished into three sorts, namely, the fore, or front teeth, which are erect, parallel, and wedge-shaped, are denominated *incisors*, or *cutting teeth*, standing close together, and more equal and round than in other animals; secondly, the *tusks*, *eye-teeth*, or *corner-teeth*, of which there is only one, on each side of the fore-teeth, in each jaw, a little longer than the fore-teeth, but much less so than in other animals, and placed close to the other teeth; and, thirdly the *grinders*, of which there are five on each side in both jaws, blunt, and divided, on their upper surface, into pointed eminences, though these last are not so remarkable as in other animals. The ears are placed on the sides of the head, are of an oblong rounded figure, with a semilunar curve on their anterior edges, lying flat to the head, naked, arched at the margin on their upper and posterior edges, and thicker, and soft at the under extremities.

The trunk of the body consists of the neck, breast, back, and belly. The neck is roundish, and shorter than the head; its chine-bones are not, as in most animals, connected by a suspensary ligament; the nape is hollowed; the throat, immediately below the chin, is hollow at its upper part, and protuberant in the middle, a little lower down. The breast is somewhat flattened both before and behind; on the fore part there is a depression, where it joins with the neck; the arm-pits are hollow and hairy; and the pit of the stomach is flat. On the breast are two distant, round, protuberant mammæ, or dugs, each having a cylindrical, obtuse, wrinkly, projecting nipple, which is surrounded by a darker coloured circle, called the *areola.* The back is flat, having protuberances at each side at the shoulder blades, with a furrow or depression between them. The abdomen, or belly, is large and protuberant, with a hollow at the navel; the epigastric regions, or sides of the belly, are protuberant; the groins flattish and hollowed. The pubes is hairy; the pelvis, or basin, is wider above, and grows narrower below. The male parts are external and loose; the penis cylindrical; the scrotum roundish, lax, and wrinkled, being divided in the middle by a longitudinal ridge, or smooth line, which extends along the whole perinæum. The female parts are compressed and protuberant, having labia, nymphæ, clitoris, and hymen, and, in adults, secreting the catamenia. The limbs consist of arms and hands, and of thighs, legs and feet. The arms are placed at a distance from each other; they are round, and about a foot in length from the joint of the shoulder to the elbow; the fore arm contains two bones, and is obtusely prominent; the ulna, which forms the principal thickness of the member, is round, and somewhat flattened on the inside. The hands are flat, broad, and rounded, convex on the outside, or back of the hand, and concave on the inside, or palm. Each hand has five fingers, one of which, named the thumb, is shorter and thicker than the rest, and is placed at some distance from them; the others are near one another, and placed parallelly, the outer, or little finger, being the smallest; the second, named *index*, or *fore finger*, and the fourth, called the *ring finger*, are next in length and size; and the third, or middle finger is the longest. The point of this last, when the arm and hand hang down, reaches to the middle of the thigh. The nails are rounded and oval, and each has a semi-lunar whitish mark at the root, or lower extremity. The lower limbs are placed close together, having brawny muscular haunches, and swelling fleshy hips; the knees are obtuse, bend forwards, and have hollow hams behind. The legs, which are nearly of the same length as the thighs, are of a muscular make behind, where they swell out into what is called the *calf;* they are lean, and free of flesh only on the shins or fore parts, and taper downwards to the ankles, which have hard hemispherical projections on each side, named the *ankle bones* or *malleolæ*. The heel is thick, prominent, and gibbous, being longer and broader than in other animals, for giving a firm support to the body; and it joins immediately with the sole of the foot. The feet are oblong, convex above, and flattened on the soles, which have a transverse hollow about the middle. Each foot has five toes, somewhat bent downwards, and gibbous, or swelled underneath at their extremities; they are all placed close together, the inner, or greatest, being thicker and somewhat shorter than the rest; the second and third are nearly of equal length; and the fourth and fifth are shorter than the others, the outermost, or little toe, being the shortest and smallest.

If we compare these characters with those of the genus *Simia*, we shall find some marked points of difference: Yet Linnè himself, at one time, classed the *troglodytes* under the varieties of mankind, and certain physiologists have affected to regard them as the common source of all the diversities of the human race; or rather they affect to believe, that both man and ape have proceeded from the monkey, the tail having been progressively diminished and obliterated from want of use, or some accidental circumstances in the animal constitution. The learned and ingenious Lord Monboddo was one of the most zealous champions of this singular theory, which now scarcely requires to be refuted.

Another variety of our kind has been supposed to exist in the white and colourless individuals, denominated *albinos*; a term first applied by the Portuguese to Moors who were born white, with every other characteristic of the race from which they descended, and who, on account of this hue, were looked upon by the negroes as monsters. In these persons, however, more critical observers remarked other peculiarities than the colour of their skin; for their hair, and the iris of their eyes, were also white, and the pupil was rose-coloured. It has since been distinctly established, that this appearance indicates no particular variety, but only a morbid habit, accompanied with constitutional debility, and of which analogous instances occur in the natural history of other animals. The proximate cause of this disease is a deficiency in the secretion of the *rete mucosum*, or general colouring matter under the cuticle, which varies the complexion, the colour of the hair, and of the eyes, and the absence of which reduces the whole to the same whitish, or colourless aspect. It is sufficiently rare to induce the patient, if in the lower ranks of life, to exhibit himself for money. Saussure and Barri seem to insinuate, that it is confined to males; but this is unquestionably a mistake; for several *Albinas*, or *Albinesses*, as they have been called, have been publicly seen in London, within these twenty years; and one, if not two of them, indigenous to the united kingdom. At all events, as their offspring never fails to return to the original colour of the natives of the place, they cannot be regarded as forming a separate breed.

The same remark applies to *pyebald* individuals, whether they are born so, or become so after birth. Their parents are always, one or both of them, black; at least no example of European white parents having such offspring, has been known. It is remarkable, that the blotches are distinctly defined, the colours not running gradually into one another, as may likewise be observed in pyebald horses, cows, pigs, and dogs.

Among such anomalous deviations from the more ordinary standards, which constitute no general or permanent variety, some interesting cases have been, or remain to be cited in the articles *Giant* and *Pigmy*. Independently, however, of these extraordinary exceptions to general rules, independently, too, of the attributes of age and sex, which must be familiar to the most common observer, nature every where presents us with countless varieties and diversities in the human species, insomuch, that no two men or women, probably, ever completely resembled one another. Entirely abstracted, however, from the consideration of these infinite individual shadings of difference, is that of the more marked and graphic lineaments which discriminate whole *breeds* or *races*. In other words, there are certain common characters which appertain to all the inhabitants of a country, or nation, and which enable us to distinguish one people from another. The most careless observer will never confound a negro with a European; nor is much practice requisite to the recognition of a Chinese, a Malay, or an Englighman, by his figure, aspect, and conformation, although they should all be similarly dressed, and should speak the same language.

Agreeably to this view of our subject, the whole of the human race may be arranged under one of two great divisions. The physical characters of the first are, a complexion either fair, or merely tawny, or somewhat olive, but never black; hair straight and long, facial angle from 85 to 90 degrees, and stature very erect. The second includes all the varieties of our species, whose complexions are either very dark, or completely black, with hair more or less woolly, short, and much frizzled, lips turgid, the facial angle varying from about 75 to 82, the position of the body somewhat oblique, the hip-joint and back as if slightly deformed, the knees bending a little outwards, and the habit of going almost naked. Their intellect is supposed to be more feeble and limited than that of those belonging to the former division; and hitherto, at least, they have scarcely made any advances in science or the arts.

The first division includes three subdivisions, which may be termed the *white*, the *tawny*, and the *copper-coloured* races; and the second includes the *dark brown*, the *black*, and the *blackish*. Thus, without regard to endless hybrid and mongrel intermixtures, six races are distinctly traceable. Of these, the first, or the *white*, is principally distinguished by the straight oval face, white skin, large and straight nose, and moderately cleft mouth. The individuals of this description have their teeth placed vertically, the forehead ample, and projecting, the cheeks coloured, the lips small, the face well-proportioned; and they furnish the greatest number of beautiful human figures, and the only instances of fair and auburn hair and blue eyes. According to the comparative lightness and darkness of the complexion, they have been distributed into two families or sections.

The first, or brownest, includes the Arabs, the ancient Hebrews, the Druses, and other inhabitants of Mount Libanus, the Moors, the inhabitants of Morocco, and of the Barbary States, the Abyssinians, and the brown and sun-burnt hordes of Northern Africa. The brownest of these people acquire a fair complexion, when they cease to be exposed to the sun; but the blood of many of them has been much blended and contaminated, in consequence of the successive conquests and revolutions in which they were involved before and after the days of Mahomet. For the most part they are brave and warlike, but addicted to pillage their neighbours and travellers. Their women, in all Mahometan countries, are veiled and confined; and those of Arabia have been remarked for their beauty. The Hindoos, on this side of the Ganges, belong to the same classification; and their dark complexion obviously results from exposure to light and heat; for the Indian women of the harem or seraglio, are quite fair. Among these Hindoo tribes are reckoned the inhabitants of Bengal, those of the coast of Coromandel, the Moguls, the Malabarians, the Banians, and the people of Candahar and Calicut. These are mild tempered, superstitious, and timid, apparently relaxed and enervated by heat. They are capable of exercising much minute industry; but the despotic form of their governments, and their physical languor, detract from the practical energy of their talents. Their religion, founded in idolatry, enjoins the cultivation of the soil, the multiplication of the human species, and the maintenance of particular castes, whilst it prohibits the shedding of the blood of animals. The Persians, Armenians, and the inhabitants of Chorazan, Syria, Georgia, and Mingrelia, are seldom deficient in courage, are addicted to traffic and war, and consist of Mahometans and oriental Christians. In some of the last mentioned districts, the women are celebrated for their beauty, but they are objects of traffic, and of such wretched jealousy as to be guarded by eunuchs. Several of these tribes are addicted to the habit of painting their skin of various colours; and the women of Lahor, Cachemire, &c. frequently extract all the hairs from their body, and deck themselves out with a profusion of jewels. The Armenians are Christians of the Eutychian sect, and the Malabarians, Banians, &c. believe in the metempsychosis, or transmigration of souls.

The second family of the white race comprises the Europeans, their colonists in America, in the East and West Indies, &c. the Caucasian tribes of Usbecs, ancient Scythians, Turks, most of the Muscovites of Europe, the nations of the Crimea, of Kuban, and others which confine on the Black Sea, the inhabitants of the Ukraine, of the provinces of Astrachan, &c. The civilized Europeans of the *Celtic* stock, as they have been denominated, viz. the Spanish, Italians, Greeks, French, British, &c. betray a decided aptitude to the improvements and accommodations of social life, and are conspicuous for activity, ingenuity, and enterprize; while their governments are administered with comparative moderation, and the religion which they profess is highly favourable to the promotion of the best interests of the individual and of society. Among most of the Caucasian stock, again, we may remark a robust body, courage, verging on ferocity, and impetuous and warlike dispositions, but little propensity to the pursuits of science, or to the culture and intercourse of civil life. Hence their familiarity with revolt, war, rapine, and tyranny, to which we may add, their love of luxury, and of intoxicating liquors.

2. The *tawny*, or *olivaceous* race has, for distinctive characters, a broad, flat, and compressed countenance, a thick and flat nose, wide nostrils, large and prominent cheek bones, a flat and very broad upper jaw, hollow temples, the eye-lids imperfectly opened, the eyes at considerable distance from each other, and the chin projecting. In all climates, the complexion of this race is tawny, or approaching to the hue of the dried peelings of oranges; the hair is always black, thinly scattered, coarse and lank. The countenance exhibits a sort of losange, or square, with a very scanty natural beard; and the iris is always black. The stature is short and squat, the body square and muscular, and the legs short and somewhat arched, or gibbous.

This race, the most numerous of all, has been distributed into three families, that, namely, of the Mongolian Calmucs, with forms more softened than those of the other two, that of the Chinese, and of other nations of eastern Asia, beyond the Ganges, and that of the Laplanders, Ostiacs, Samoiedes, Kamtschadales, and the borderers on the Arctic pole. They are all extremely tenacious of long established usages.

The first of these families, in Europe, is composed of the Hungarians; in Asia, of the Siamese, Peguese, Cochinchinese, Tonkinese, Chinese, Coreans, Japanese, Chinese Tartars, Thibetians, and Mongolians. Their complexion is swarthy, and their features are less rude than those of the Calmucs. Most of them live under fixed despotical governments, tempered, however, by the native mildness of their dispositions, which are little suited to the roughness of the military life. Their religion, which consists in the worship of the grand lama, Brahma, idols, &c. is more or less interwoven with the frame of their governments, and prescribes absolute subjection to existing power. The Hungarians, however, on the one hand, and the erratic Mongul-Tartars on the other, are excepted from this remark. In China and Japan, small feet are highly prized by the women: and the inhabitants of Aracan, Laos, Siam, and Pegu, delight in long ears, and dye their teeth black. These people, though gentle and timid, are cunning and knavish, readily sacrificing their principles and feelings to considerations of gain. Though the Chinese and Japanese are reputed the most anciently civilized tribes of Asia, yet they have for ages remained stationary in the career of arts and policy, being pertinaciously averse to the adoption of new discoveries or improvements.

The second section of this race embraces the great family of Mongul-Tartars, such as the Mantchoos, Calmucs, the genuine Cosacs, Burats, and the Tangutian hordes that border on Thibet, and on the north of China. These are nomadic tribes, living in tents, and roaming on horseback over the immense plains of Tartary, not cultivating any particular spot, feeding on the milk of mares, and the flesh of horses, which last they often eat raw. Being always armed, they make war like banditti, and fight for plunder rather than for conquest. Yet they manifest much personal bravery, and obey an elective chief, called *Khan*, whom they invest with sovereign authority. Though designated *Tartars*, they are to be carefully distinguished from those of European Russia, who belong to the white race.

The third section includes the polar tribes, distinguished by their thick and reduced stature, such as the Laplanders, Nova-Zemblians, Samoiedes, Ostiacs, Tungusians, Jakutes, Tschutkis, and Kamtschadales, in the old continent, and the Esquimaux and Greenlanders in the new. These men, who rarely exceed four feet in height, confine on the polar circle, and are remarkable for the coarseness and filthiness of their manners, and their infatuated attachment to their native soil, notwithstanding the hardships and privations to which they are unavoidably subjected.

3. The *copper-coloured* race is composed of the aboriginal American tribes that occupy the regions which intervene between Quebec, the Mississippi, and California,

on one hand, and the Straits of Magellan on the other. Their forehead is very short and depressed; their eyes sunk; the nose somewhat broad, the nostrils very open; the hair black and lank; the skin of a red copper tint, and thinly scattered with hairs, which they pluck out. Their countenance is generally broad; their cheeks are elevated; their bodies muscular; their aspects wild and savage. They frequently paint their bodies, and are found naked, even in latitudes in which a considerable degree of cold prevails. Their more northerly hordes, as the Canadians, Iroquois, Natches, Algonquins, and Hurons, are courageous and warlike, outrageous in revenge, and capable of enduring torture with a firmness and composure unknown to the generality of mankind. They worship idols, called *manitous*, and also pay homage to the sun and stars. The chiefs of the Natches even pretend to derive their descent from the sun, and, like the Incas of Peru, regard that luminary as the Supreme being. When the Spaniards first landed in America, they found two extensive empires existing, that, namely, of the Incas or Peruvians, and that of Mexico; but a handful of European adventurers sufficed for their subversion, and butchered many thousands of Americans. The Spanish historians have probably exaggerated the opulence, splendour, and resources of these semi-barbarous states; for the vaunted Mexicans and Peruvians were ignorant of the use iron, coin, alphabetical writing, and proper clothing; and they consecrated virgins to the sun, and immolated men to their sanguinary deities. At the southern extremity of America, we find the Patagonians, a nomadic horde, almost naked, or covered with skins, who subsist on the produce of the chase, devour the raw flesh of seals, and who have been falsely represented as a race of giants. All the idolatrous American Indians indulge in polygamy, delight in war, hunting, fishing, the parade of ornament, and spiritous liquors. They are alert and indefatigable in their long marches, but phlegmatic, vindictive, and patient under torment. They elect chieftains, or *caciques*, from among themselves, and are governed, in the form of petty and rude republics, by their respective usages.

4. The people who compose the *dark-brown* race are generally called *Malays*, from the peninsula of Malacca, whence they derive their chief origin. Their forehead is depressed, but rounded; the nose full and broad, thick at the extremity, and the nostrils widely separated; the mouth is very large; the cheek-bones moderately high; the upper jaw somewhat less projecting than in the negro, but more so than in the Calmuc; the facial angle from about 80 to 85; the hair thick, and pretty long and soft; its colour, and that of the eyes, always black. This race, which seems to form a link between those of the Mongolians and negroes, occurs in the interior of the island of Madagascar, in Ceylon, Sumatra, Java, Borneo, the peninsula of Malacca, and in most of the islands of the Indian Archipelago, as well as in New Zealand, the South Sea Islands, &c. They are an active sea-faring people, engrossed in petty trafficking, or brokerage, bold, crafty, eagerly covetous of gain, fierce, cruel, and, in their wars, even addicted to cannibalism. They are, for the most part, polygamous, seldom submit to clothing, and, like many other naked savages, paint or tatoo their skins. Their religion is a sort of childish idolatry, little elevated above that of the negroes; and their political constitutions have the semblance of feudal republics. Their language is uncommonly vocal.

5. The more obvious characters of the *Black* or *negro* race, can scarcely fail to be familiar to us, such as the depressed and rounded fore-head; the head compressed towards the temples, the teeth placed obliquely and projecting, the body and neck stretching forward, the black complexion, frizzly hair, flat nose, thick lips, deficiency of calves to the legs, &c. Many more minute characteristics are stated by Professor Soemmering in his Essay on the Comparative Anatomy of the Negro and European; but the recapitulation of which would needlessly extend this abbreviated sketch.

Monsieur Virey, and others, distinguish the black race of mankind into two branches, namely, that of the *Ethiopians*, or *negroes*, properly so called, and that of the *Caffres*. The first family includes the Joloffs, Foulas, the inhabitants of Senegal, Sierra Leone, Maniguetta, the Gold Coast, Benin, Loango, Congo, &c.; in short the whole western coast of Africa, from the Senegal to Cape Negro, to which we may add the Cape de Verd Islands. The negroes are discriminated from the Caffres by their more rank odour when heated, by their oily satiny skin, and by a deeper sable tint. Among them are some circumcised mussulmens, but most of them are devoted to the grossest idolatry, appear to have a very circumscribed range of intellect, would cultivate their patches of grain in peace, but are controlled by petty princes, who frequently excite them to war for the sake of selling them into slavery—a scandalous scene of cruelty and oppression, which only now begins to give way before the more enlightened humanity of the times.

The Caffres inhabit that eastern region of Africa which extends from the Fish river to the Straits of Babelmandel, a vast territory, comprising Monomotapa, Caffraria, all the coast of Zanguebar, or the Mozambique, Monemugi, &c. &c. They are readily distinguished from the negroes by superior talents and more warlike dispositions. Their black tinge is less deep and less glossy; their face less lengthened; their features more regular and handsome; their body very robust, and well constructed, and taller and more slender than that of the negroes; nor do they exhale any disagreeable odour when over-heated. Their habits are chiefly pastoral; and they travel on horses or caravans from one grazing district to another, constructing temporary huts, living on milk, cheese, and flesh, seldom cultivating any ground, and always armed with their *zagaies*, or spears, which they dart to a great distance with much vigour and address. They also traffic in cattle, peltry, ivory, gold dust, &c. They entertain ideas of the Supreme Being and his power; and, being partial to fatalism, occasionally embrace the faith of Mahomet. They will meet an enemy openly and boldly; are impatient of slavery, and, consequently, seldom subjected to its endurance; for when deprived of their liberty they are not, like the negroes, to be cajoled and diverted by trifling amusements; but they readily submit to habits of domestication. They are habituated to polygamy, and are governed by a general, chief, or king, whose power is very limited, but who appoints the sub-ordinate chiefs over the different hordes, and through them conveys his directions or commands.

6. This race is distinguished from the preceding by a still more elongated snout; a triangular visage, terminating in a point; a facial angle of about 75 degrees; by a skin of a brown black, or umber hue; widely separated eyes, always half closed; a very depressed and

very wide nose; lips more turgid than even those of the negro; hair resembling balls of felt; very salient cheek-bones, and a fore-head so depressed as to be hardly distinguishable. They are all remarked for their stupidity, laziness, and sensuality. They have been divided into two varieties, or principal families, both resident in the southern hemisphere. The first comprehends the Hottentot tribes, and the second, the savages of New Guniea, New Holland, and New Caledonia.

The Hottentot population stretches over the whole southern extremity of Africa, from Cape Negro to the Cape of Good Hope, and from the latter to Monomopata, embracing a great variety of districts. Such of them as the Dutch distinguished by the name of *Boschmen* are particularly savage, concealing themselves in woods, or caverns, whence they make sudden excursions, for the purpose of pillage, subsisting on prey and wild roots, having scarcely the use of articulate speech, and being hardly more sociable than the beasts of the forest. The other Hottentots also live without laws or fixed regulations, but are generally gentle and inoffensive; but they are notorious for the nastiness of their persons, the filthiness of their manners, and their fondness of tobacco. Their language resembles a disagreeable clacking noise; and their religion appears to be limited to the worship of some petty idols, and the predictions of a sort of soothsayers.

The islanders of New Guinea love war, without evincing much personal bravery, and chiefly subsist on the spontaneous produce of their fertile soil. The natives of New Holland again exhibit every appearance of wretchedness, picking up shell-fish, the refuse of the sea, and some harsh fruits, and wild roots. They paint their naked bodies, and though they swim well, they have never attained to the construction of a boat. They seem to be almost incapable of reflection, often squatting down for a whole day in listless apathy, or crawling under slender hovels, in which they cannot stand erect. Their lances, which they dart with dexterity, are pointed with a bone or sharpened stone. The inhabitants of the southern extremity of Van Diemen's land and of New Caledonia may rank a little higher in the scale of intellect; for they fence themselves against the cold with clothes, and are somewhat more active in their movements than the Hottentots. Their hair, which is much frizzled, runs less into balls than that of the Hottentots; and they powder it either with a reddish earth, or with the lime of oyster-shells.

From the preceding rapid survey of some of the principal varieties of our species, it is manifest, that man is, physically speaking, a cosmopolite, or an inhabitant of the world at large, being capable of sustaining the cold of the polar, and the heat of the equatorial regions.—A faculty which has been denied to most other animals.

A question, however, naturally arises, whence the diversities and shadings of his kind? Have they arisen out of accidental circumstances, or were their prototypes originally created, with the aspects and attributes which our present state of knowledge has assigned to them? Philosophers have not been wanting, who have multiplied the *species* of men in exact proportion to their *varieties*. But, although considerations of climate, food and social habits, will not adequately account for the permanence of the differences to which we have alluded; yet, so long as all the varieties sexually unite, and produce a fertile offspring, and so long as they merely exhibit an analogy to what takes place among other gregarious and domestic animals, we are not warranted to infer that they constitute distinct species. Some physiologists, according to the learned and ingenious Professor Blumenbach, having embraced too narrow views in their researches, selected, perhaps, two races, the most distant from each other possible, and overlooking the intermediate races that formed the connecting links between them, compared these two together; or, fixing their attention too exclusively on man, they have neglected the examination of other species of animals, and compared their varieties and gradations with those of the human species. An example of the first error in reasoning on this subject is, when one confronts a negro of Senegal with an adonis of Europe, without recollecting that there is not one of the bodily differences of these two beings, be it hair, colour, features, &c. which does not gradually run into the same thing of the other, by such a variety of shades, that no physiologist is able to draw a line of demarcation between these gradations, and, consequently, between the extremes themselves. The second error is, when people reason as if man were the only organized being in nature, and consider the varieties in his species to be strange and problematical, without reflecting, that all these varieties are not more striking or more uncommon than those with which so many thousands of other species of organized beings degenerate, as it were before our eyes. This position he thus happily illustrates by a curious camparison between man and swine.

" More reasons than one have induced me to make choice of swine for this comparison; but in particular, because they have a great similarity, in many respects, to man: not, however, in the form of their entrails, as people formerly believed, and therefore studied the anatomy of the human body purposely in swine; so that, even in the last century, a celebrated dispute which arose between the physicians of Heidelberg and those of Durlach, respecting the position of the heart in man, was determined, in consequence of orders from government, by inspecting a pig, to the great triumph of the party that was really in the wrong. Nor is it because, in the time of Galen, according to repeated assertions, human flesh was said to have a taste perfectly similar to that of swine; nor because the fat and the tanned hides of both are very like to each other; but because both, in regard to the economy of their bodily structure, taken on the whole, shew unexpectedly, on the first view, a very striking similitude.

" Both, for example, are domestic animals; both omnivorous; both, are dispersed throughout all the four quarters of the world; and both, consequently, are exposed, in numerous ways, to the principal causes of degeneration, arising from climate, mode of life, nourishment, &c. Both, from the same reason, are subject to many diseases: and what is particularly worthy of remark, to diseases rarely found among other animals than men and swine, such as the stone in the bladder; or to diseases exclusively peculiar to these two, such as the worms found in measled swine.

" Another reason why I have made choice of swine for the present comparison is, because the degeneration and descent from the original race are far more certain in these animals, and can be better traced, than in the varieties of other domestic animals. For no naturalist, I believe, has carried his scepticism so far as to doubt the descent of the domestic swine from the wild boar, which is so much the more evident, as it is well known that wild pigs, when caught, may be easily rendered as tame and familiar as domestic swine: and the contrary is also the case; for if the latter, by any accident, get into the woods, they as readily become wild again, so that there are instances of such animals being shot for wild swine; and it has not been till they were opened and found castrated, that people were led to a discovery of their origin, and how and at what time they ran away. It is well ascertained, that, before the discovery of America by the Spaniards, swine were unknown in that quarter of the world, and that they were afterwards carried thither from Europe. All the varieties, therefore, through which this animal has since degenerated, belong, with the original European race, to one and the same species; and since no bodily difference is found in the human race, as will presently appear, either in regard to stature, colour, the form of the cranium, &c. which is not observed in the same proportion among the porcine race; while nobody, on that account, ever doubts that all these different kinds are merely varieties that have arisen from degeneration, through the influence of climate, &c. this comparison, it is to be hoped, will silence those sceptics who have thought proper, on account of these varieties in the human race, to admit more than one species.

"With regard to stature, the Patagonians, as is well known, have afforded the greatest employment to anthropologists. The romantic tales, however, of the old travellers, who give to these inhabitants of the southern extremity of America a stature of ten feet and more, are scarcely worth notice; and even the more modest relations of later English navigators, who make their height from six to seven feet, have been doubted by other travellers, who, on the same coast, sought for such children of Enoch in vain. But we shall admit every thing that has been said of the extraordinary size of these Patagonians by Byron, Wallis, and Carteret, the first of whom assigns to their chief, and several of his attendants, a height of not less than seven feet, as far as could be determined by the eye; the second, who asserts that he actually measured them, gives to the greater part of them from five feet ten inches, to six feet; to some six feet five inches, and six feet six; but to the tallest six feet seven inches; and this account is confirmed by the last mentioned of the above circumnavigators. Now, allowing this to be the case, it is not near such an excess of stature as that observed in many parts of America among the swine, originally conveyed thither from Europe.

"The natives of Guinea, Madagascar, New Holland, New Guinea, &c. are black; many American tribes are reddish-brown; and the Europeans are white. An equal difference is observable among swine in different countries. In Piedmont, for example, they are black. When I passed through that country during the great fair for swine at Salenge, I did not see a single one of any other colour. In Bavaria they are reddish-brown; in Normandy they are all white.

"Human hair is, indeed, somewhat different from swine's bristles; yet, in the present point of view, they may be compared with each other. Fair hair is soft, and of a silky texture; black hair is coarse, and among several tribes, such as the Abyssinians, Negroes, and the inhabitants of New Holland, it is woolly, and most so among the Hottentots. In like manner, among the white swine in Normandy, as I was assured by an incomparable observer, Sulze of Bonneburg, the hair on the whole body is longer and softer than among other swine; and even the bristles on the back are very little different, but lie flat, and are only longer than the hair on the other parts of the body. They cannot, therefore, be employed by the brush-makers. The difference between the hair of the wild boar and the domestic swine, particularly in regard to the softer part between the strong bristles, is, as is well known, still greater.

"The whole difference between the cranium of a Negro and that of an European is not, in the least degree, greater than that equally striking difference which exists between the cranium of the wild boar, and that of the domestic swine. Those who have not observed this in the animals themselves, need only to cast their eye on the figure which Daubenton has given of both.

"I shall pass over less national varieties, which may be found among swine, as well as among men, and only mention, that I have been assured by Mr. Sulze, that the peculiarity of having the bone of the leg remarkably long, as is the case among the Hindoos, has been remarked with regard to the swine in Normandy.—'They stand very long on their hind legs,' (says he in one of his letters;) 'their back, therefore, is highest at the rump, forming a sort of inclined plane; and the head proceeds in the same direction, so that the snout is not far from the ground.' I shall here add, that the swine, in some countries, have degenerated into races, which, in singularity, far exceed every thing that has been found strange in bodily variety among the human race. Swine with solid hoofs were known to the ancients, and large herds of them occur in Hungary, Sweden, &c. In like manner, the European swine, first carried by the Spaniards, in 1509, to the island of Cuba, at that time celebrated for its pearl fishery, degenerated into a monstrous race, with hoofs which were half a span in length."

From the foregoing facts, our author concludes, that it is absurd to allow the vast variety of swine to have descended from one original pair, and to contend that the varieties of men are so many distinct species.

We have had recourse to this train of argumentation, chiefly with a view to meet the objections of those who, either disbelieving the authenticity of the Mosaic account of the creation, or regarding it as merely allegorical, have impugned its consistency with their alleged state of physical facts.

If we next contemplate the human *individual* from his cradle to his grave, we shall find him commencing his career with the painful sensations of being ushered into the open air, a very different element from the gentle warmth of the mother's womb, expressing his uneasy feelings by cries, and exhibiting an interesting spectacle of signal helplessness and want. At that period, more destitute and dependent than any of the inferior animals, he would speedily perish, did not his very weakness and impotence conjure up around him the most tender and unwearied protection and sympathies. Not only, however, is his inability to provide for his urgent wants complete; it is, moreover, prolonged beyond the term of imperfection assigned to other animals. Yet Nature, or, to speak more correctly, the Author of Nature, does nothing in vain; for it is wisely and kindly ordained, that a being, destined to exist and act his part in society, should long experience the influence of affectionate care and discipline, and that parents, nurses, and guardians, should be prompted to the discharge of their impor tant duties by the purest of all rewards—that indescribable gratification which flows from the interchange of endearing feeling, and from the consciousness of affording comfort and protection to helpless unsuspecting innocence.

The new-born infant usually measures about 21 inches in height, and weighs from 10 to 15 lb. A portion of the skull, on the crown of the head, remains for some time unconsolidated; a circumstance which has not been observed of other animals, and which has probably a reference to the exigencies of gestation and parturition, the child having a larger head, in proportion, than the young of the inferior animals, and requiring accommodation to cases of pressure. Its bones, too, are still of a cartilaginous consistency; its extremities small; the flesh very soft, gelatinous, and humid; the vessels and nerves large; the belly distended; the cellular texture relaxed, spongy, and full of lymph; the eyes dim, fixed, and commonly blue; the cornea wrinkled, and the retina, perhaps, too soft for receiving impressions of external objects. The other external senses are likewise very imperfect; for the auditory passage is stopped up with mucous matter, which deadens the sensation of sound; the pituitary sinuses, lined with a viscid humour, are incapable of perceiving odours; the skin, as yet too soft and yielding, can communicate no adequate ideas of touch; and the papillæ of the tongue are too much blunted to discriminate savours. The paramount sensation is that of the mother's breast, to which the babe instinctively clings, and receives its nourishment. At the same important epoch, a material change is effected in the circulation of the blood; for the air, acting on the olfactory nerves, and on the organs of respiration, produces a shock something like that of sneezing, expands and elevates the breast, induces a discharge of mucous matter from the nostrils, and thus facilitates the entrance of the vital element into the lungs, and the blood penetrating into these viscera, and being there impregnated with air, receives its florid hue, returns to the heart, and is gradually diffused through the body, instead of immediately passing, as in the fœtus, from the right to the left ventricle of the heart. The breast is seldom presented to the child till at least ten or twelve hours have elapsed; and as the first milk, technically termed *colostrum*, is usually of a serous and laxative quality, it aids the expulsion of the blackish contents of the intestines, called *meconium*. In the course of a few days, the infant usually experiences a slight degree of jaundice, when the bile and the hepatic system begin to exercise their functions. Much of its time is passed in sleep, and it applies its lips to the breast almost as often as it awakes. About the fortieth day from birth it begins to smile, and to recognize the features of those who approach it. *Incipe, parve puer, risu cognoscere matrem.* At the expiration of six or seven weeks, a little panada, or some such light food, may be added to the mother's milk; but it is generally reckoned advisable to defer weaning till the period of dentition. In Holland, Italy, Turkey, and the Levant, the food of children is limited to the milk of the nurse for a whole year; and the savages of Canada give their children suck for four, five, six, and sometimes even seven years.

The cutting of the teeth, contrary to what takes place in most natural processes, is always accompanied by more or less irritation of the system, and often by very painful and distressing symptoms, when the quantity of aliment should be considerably reduced, and the febrile heat still further diminished, when the weather permits, by exposure to the open air. Children, in this state, instinctively apply their fingers to the mouth, to relieve the irritation of the gums; and some benefit is frequently derived from putting into their hands a bit of ivory, or coral, or of some other hard and smooth body, with which they rub the gums at the part affected. The eight incisive teeth, of which four are placed in front of each jaw, usually make their appearance in eight or ten months: the four canine, or eye-teeth, pierce the gum about the tenth month; and, in the twelfth or fourteenth month, the jaw-teeth, or grinders, are gradually protruded, to the number of sixteen—thus making twenty-eight teeth in all. At the age of twenty-six or thirty years, four grinders, namely, two at the bottom of each jaw, and, on account of their tardy appearance, commonly called *wisdom teeth*, are developed, which complete the number of 36: but these last are not always present in the female subject. Whoever is much conversant with the infantine condition of our race must also have observed, that the periods, modes, and symptoms of dentition vary very considerably in different individuals. Towards the age of six or seven years, a new impulse being given to the nutritive system of the child, he not only acquires an accession of vigour, but his incisive milk-teeth are shed, and replaced by others of larger dimensions and stronger texture. The four canine, and the first four grinders, are, in like manner, supplanted by others. Children have been occasionally born with their incisive teeth already cut.

The hair of new-born infants is always more or less fair in the European, but black in the other breeds of mankind: and it is somewhat singular that the same remark should be applicable to the iris of the eye. The hair and eyes assume a darker colour as the individual advances in life, and they lose their peculiar hue on the approach of old age. The children of negroes, and of people whose skin is very dark, are born white or reddish, but they gradually acquire their appropriate tint, even though not exposed to the sun.

Notwithstanding the extreme delicacy of the infantine frame, it is less susceptible of cold than that of adults, the more rapid circulation inducing a greater degree of internal heat.

Children usually make their first efforts to speak about the age of twelve or fifteen months, though some only at two years and a half or three years, or even later.

The growth of children, like that of the inferior animals, is rapid in proportion to the youth of the animal, and to the quantity of nourishment digested. It has likewise been observed, that it is more considerable in summer than in winter. As the fœtus was at all times nourished with the maternal blood, its dimensions were quickly unfolded: the child, in like manner, suckles and eats often, and grows faster than the young man, who eats less in proportion to his bulk. Besides, in proportion as the organs become dry and solid, they increase more slowly in dimensions, the fibres become less flexible, the channels are gradually obstructed, interstices are filled up, and the food is discussed with more difficulty, till, being no longer requisite for the composition and increment of organs, it is secreted in the form of fat, or converted into the materials of reproduction. Some children grow much more rapidly than others, and manifest a greater degree of precocity in their whole economy. Girls, too, are sooner mature than boys, because, perhaps, their organization requires less solidity and nutriment, or because the sensibility of their nervous system communicates a greater impulse to their growth.

The next marked stage in the progress of the human being, is that of *puberty*, which is indicated by the developement of the generative organs, and the incipient symptoms of the amorous passion. The approach of this term is considerably accelerated or retarded by the circumstances of sex and climate, but, in our temperate latitudes, may generally be reckoned as dating its commencement at sixteen years of age in boys, and fourteen in girls. A male inhabitant of the arctic regions, however, seldom reaches to this change in his constitution before his 18th, or even his 20th or 22d year; nor, in such high latitudes, are the girls marriageable before eighteen or nineteen, whereas a Hindoo or Arab youth is mature at thirteen or fourteen, and a girl at eleven or twelve. But such prematurity of constitution is followed by early extinction of the sources of reproduction, which are usually quite exhausted at the age of thirty, whilst in this country, in which virility is more slowly attained, the constitution has time to acquire solidity and vigour, so that females continue fertile till forty-five or fifty, and males are capable of propagating at sixty years of age. Other circumstances likewise contribute to influence the state of puberty, such, for example, as the quantity and quality of food, constitutional tendencies, and moral causes. Thus, persons who have been accustomed to a copious and nutritive diet, or to heating and stimulating meats and drinks, have their sexual faculties sooner unfolded than those who have been condemned to scanty or unwholesome fare, or who have been restricted to a cool and abstemious system of nourishment. In our populous cities too, where too many excitements constantly solicit the senses and the imagination of the young, puberty frequently supervenes more early than in our villages and hamlets, where labour, simplicity of manners, and the absence of many illusions, retain the youth in the tranquillity of ignorance. Although the emotions of love and sex begin to predominate at the age of puberty, yet they are seldom wholly unknown before that crisis, though they are often limited to ideas of vague, undefined curiosity. In every well-regulated mind, they are, moreover, accompanied and counteracted by feelings of chastity, to which the inferior animals appear to be strangers. They are likewise kept in check by the greater scope which is then given by nature to the intellectual and reasoning powers, as well, perhaps, as by that romantic and sentimental melancholy, and that manliness and generosity of conduct, which are more or less characteristic of the age of youth. During infancy and childhood, the vital functions exercised their energies on the organs of nutrition, and on the cellular and lymphatic systems, being wholly expended on the general growth. In proportion, however, as the individual emerges into the state of puberty, the vital efforts are more particularly directed to the glandular and generative systems. The organs of voice, too, experience a remarkable change, because the muscles of the glottis receive an enlargement, which renders the sounds uttered from the mouth more deep and hollow, by nearly a whole octave. Hairs spring from the arm-pits, about the breasts, &c. but the beard seldom appears till the nineteenth, twentieth, or twenty-first year. In the female, the glands of the mammæ receive a considerable expansion, the nipple enlarges, reddens, and acquires a considerable degree of sensibility, at the same time that menstruation takes place. Whether it be true, as has been alleged, that the bodily strength and manly deportment of youth depend on the resorption of part of the seminal fluid into the system, certain it is, that its improvident expenditure entails on the wretched victim langour, disease, imbecility, and premature decline.

Soon after the age of puberty, the body of man attains to its full stature, though this term, too, is liable to vary; for some cease to grow after fifteen or sixteen, whilst others continue to increase in height till twenty, or even twenty-three. During this interval they are usually very slender, but, by degrees, the limbs swell, and assume their proper shape; and, before the age of thirty, the body has generally arrived at its greatest perfection with regard to strength, consistency, and symmetry. The powers of the mind, too, at this period, have been matured, and have qualified us for discharging the duties of professional situations, and for relishing the rational pleasures of social and virtuous intercourse. Many, however, never reach the perfect term of their existence; for multitudes of our race perish during infancy and childhood; and not a few are daily cut off in the blossom of their days: individuals, in short, as in the other classes of animals, hourly disappear, but the race abides. From a comparative view of many tables of mortality, it results, that one-fourth of the children born in the course of a year perish before the complete revolution of five years, one-third before the revolution of ten years, one-half before 35 years have elapsed; two-thirds before the accomplishment of 52 years; and three-fourths before the completion of 61. Of six or seven children born in the same year, only one, on an average, attains to 70 years; of ten or eleven, one who arrives at 75; of 17, one reaches 78; of 25, or 26, one lingers on to 80; of 73, one advances to 85; of 205, one realizes 90; of 730, one prolongs his existence to 95; and of 8179, one may complete a century. It is scarcely necessary to observe, that immediately after the creation, when the world was destined to be peopled by one man and one woman, the ordinary term of life somewhat exceeded 900 years; that immediately after the flood, when there were three males to stock the world, this term was considerably abbreviated, Shem having been the only patriarch who attained to 500. In the second century of the world, we hear of none who reached 240; in the third, none, except Terah, who saw 200. By degrees, as the numbers of mankind increased, longevity dwindled, till the days of Moses, when seventy, or, at most, eighty years, were reckoned about the extreme term of human existence. Since that period, the ordinary duration of man's life appears to have been pretty stationary in all ages; for, not to mention the instances which might be quoted from the sacred scriptures, Plato lived to eighty-one, and was accounted an old man; and the examples of long life adduced by Pliny, as very extraordinary, may, most of them, be matched in our modern tables of well attested cases. Thus, the astonishing age of 175 was realized in the person of Louisa Trexo, a negress, and a native of Tucomea, in South America, who died in 1780. The celebrated Thomas Parr, a native of Shropshire, reached 152, and Henry Jenkins, of Yorkshire, 169. These, however, are very rare and single exceptions to the more ordinary standard, and need not to detain us longer. The average life of a child of one year of age, and that of a young man of 21 years, have been estimated at 33 years. A man of 66 years of age, has an equal chance of life with a new born infant. An individual of 10 years of age, has a probable expectancy of 40 years more of life; at 20, he may reckon on nearly 33½; at 30, on 28; at 40, on 22; at 50, on 16 years, and seven months; at 60, on eleven years, and one month; at 70, on six years, and two months; at 75, on four years and a half; at 80, on three years, seven months; and at 85, on three years. In our European climates, the average calculation of mortality, ranges at from one dead person for every 32, 33, 34, or 35, living. In London, Paris, and some other large and populous cities, the mortality is more considerable than in the smaller towns and villages. The proportion of men who perish, somewhat exceeds that of women; and the commencement of spring, and the end of autumn, are, generally, the seasons of the year most fatal to human life, on account of the marked change of the seasons. In Asia, and under the tropics, where there are only two seasons, the most sickly months are those in which the change of these seasons takes place. Certain critical revolutions in the human constitution, likewise, have been observed, though by no means invariably, to be unfriendly to the continuance of life, as, for example, the first and second periods of dentition, the age of puberty, that of complete growth, that of matured physical strength, the commencement of declension, &c. Hence the climacteric years of the ancients, and of some of our modern physiologists.

At all events, the structure and activity of our frame have scarcely reached their consummation, when they begin to be impaired. From 40 or 45, till 60 or 65 years of age, the force of vitality usually experiences diminution, the skin becomes lax, furrowed, and discoloured, the form of the limbs is more rough and angular, the cellular membrane shrinks apace, and reveals a more prominent definition of the muscles, which, in time, become more rigid, and act more slowly. In proportion as age advances, all the fibres become harder, the veinous system of circulation prevails over the arterial, so that the processes of assimilation and nutrition are more languidly performed, the glands are contracted in volume and action, the humours assume more consistency, and, at the same time, become more acrid, the secretions are less abundant, the energies of the senses, especially of sight and hearing, fail, decrepitude, and frequently a state of second childhood, supervene, and dissolution at length consigns us to that "narrow, but hospitable home, which nature has provided for all her children."

For further information relative to the preceding particulars, we beg leave to refer to Virey's *Histoire Naturelle du Genre Humain*; Kames's *Sketches of the History of Man*; Buffon's *Natural History of Quadrupeds*; Smith's *Essay on the Causes and Variety of Complexion in the Human Species*; White's *Account of the regular Gradation in Man*; Soemmering's *Essay on the Comparative Anatomy of the Negro and European*; Herder's *Outlines of the Philosophy of the History of Man*, *&c. &c.* (H. N. A.)

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MEAD, Dr. Richard. See Medicine.

MEADOWS is the name generally given to lands which abound in perennial grass, applied for the purpose of supporting live stock, either in pasturage, or when the produce is cut down and used green, or dried into hay. According to this definition, the object of the present article is to present a description of natural meadows, as distinguished from grass-lands in tillage, and from ordinary pasture lands not adapted for being used as hay-grounds. But this distinction is not extended so far as to exclude the view of improvements on lands occupied as meadow-grounds. On the contrary, this view, taken in connection with the most profitable economical application of the produce, enters into the radical purposes of the following article. The general description and management of grass lands, which come under the system of tillage in their course, will be found in the article Agriculture; and that of water-meadows in part under the same, and under that of Irrigation. Other varieties of grass lands, rich enough to be denominated meadows, fall to be treated of in the present article.

We do not mean to give any description of those vast and grassy plains which, in various countries, are neither occupied by domesticated animals, nor applied to useful purposes by human industry. The plains of South America may yet be occupied by an increased population, rather as fields than as meadows; and agriculture may convert them into corn-lands. The wide and fertile plains of the Ukraine, and of Tartary, may also in time undergo a similar transformation. But even in England, where corn is generally in so much request, the skill and experience of the farmers have led to the discovery, that meadow lands are of very great value, and form a most important object of rural economy. This, indeed, ought to be expected, in a country where live stock exists in such great numbers, and is of such importance to the comforts and subsistence of the population.

The insular situation and mild climate of the British isles being favorable to the produce of grass-lands, are of course the means of increasing the richness and value of their meadows. The arid soils and burning sun of hot climates, are unfavourable to meadows. Even in Italy, the powerful influence of water is requisite in order to maintain their verdure. The northern parts of France are more favourable, and so are the moderate climates of other countries; but the continental regions are generally too dry and clear; there is too much cold in winter, and sun during summer; and the more shaded and milder climate of these islands, (refreshed by frequent showers,) encourages and maintains a brighter verdure on the meadow-lands; while the numerous and valuable stocks require the most abundant produce, and the industry and skill of the country materially contribute in improving and enlarging that produce, and in applying it to the most useful purposes.

In cold sterile regions, neither the art nor the science of improving lands is of great avail; and, in hot sultry climates, the growth of cultivated grasses is hardly attempted, being impracticable on the drier soils, and prevented by spontaneous vegetation in the plains. But in such a climate as that of England, every thing is favourable to the culture of grass. Accordingly, the meadows of this country are of great extent, and incalculable value; and in the culture and management of these, and the application of their produce, no other country whatever can be compared with ours. Ireland, in point of soil and climate, is equally favoured, but very far inferior in actual progress; and Scotland, though less advantageously situated, may yet derive incredible benefits from the aid and example that England can furnish as to stocks and meadows.

Notwithstanding the many arguments brought forward by farmers of the highest merit and character, in favour of the system of convertible husbandry, and by which that system would be extended over the whole of the meadows, it may still be made clear to those who take a liberal and extended view of agriculture, and who allow the evidence of observation and facts,—that old grass lands, when maintained in a rich and productive state, are more valuable than the same lands would be in tillage; and there is hardly any farmer possessed of live stock, who does not concur in thinking, that every farm should possess a portion of old grass or meadow land, as a valuable accommodation.

We do not deny that grass lands, when they become covered by moss, ought to be either cured of that weed, or broken up for tillage: and indeed the latter mode of treating them is the better remedy; cultivation turning the moss plants into manure for corn. Neither would we say, that the manure which is required for corn lands ought in reason to be applied to old grass; though such mismanagement is certainly too common even in England.

The proper system of management for old grass lands is, to preserve them rich and fertile by means of such manures as may be applied, without diminishing the supplies of manure wanted for the tillage lands; thus furnishing ample stores of the best grass and hay for live stock, and thereby adding ultimately to the farm-yard manure for corn likewise.

The superior value of old grass is well known, and has been generally acknowledged. Every grazier is well acquainted with the fact; experience discovering that in pasturage it feeds greater numbers of animals to better purpose and in shorter time; and that, for the purpose of being cut into hay, it stands thicker than any new grass on the soil.

Few actual farmers are at much trouble to investigate the reasons on which this fact depends. But it may be satisfactory here briefly to remark, that a perennial sward of grass consists of such plants as are congenial to the soil, and have got the better of intruders, of course, thriving better in their natural place; that these being of great variety, and feeding at various depths, occupy the whole soil, and are found growing in full vigour, though in much greater closeness and numbers; that their mature age renders them more effective and perfect in quality; and that a firm consolidated soil thus covered, is not nearly so much hurt by the trampling of beasts on it, as a soil just laid down from tillage would necessarily be. Yet so great, of late, has been the influence of opinion among respectable practical farmers in Scotland, that even the bog meadows have been most injudiciously tortured into cultivation. It was an old error to neglect these, and to leave them unproductive; but it is an error commonly more serious, to attempt their conversion into tillage lands. The roots with which most of them abound, are hardly to be subdued by a plough; and when occupied in a proper manner as meadows, they are more productive, and of greater nett value, than as arable soils. But, in fact, the improvement and preservation of meadows are the business of landholders, rather than tenants on short leases.

For these purposes, the first object is to draw the proper lines between such lands as belong to the outer pastures, to the arable soils, and to the meadows; for we are not here entering on the subject of gardens, orchards, or pleasure grounds, but simply what may be turned into farm meadows.

It belongs to the farmer, in part at least, to fix on these lines, though he cannot well do so without the concurrence and sanction of the proprietor. Supposing it done, in so far as pertains to arable and common outer pasture lands, a proper fence to separate these will commonly leave a considerable extent of low grounds unfit for tillage, or not wanted for it. These are the natural subjects for being used as meadows.

A moderate proportion of them may be grassy in their natural state, yet capable of great improvement; and not unfrequently a large extent of these may be either barren, or beset with various obstructions. In general they may be capable of such improvements, as in time to repay the active occupier perhaps more liberally and more certainly than his arable soils. The returns, however, are not so early, which is one principal cause of preventing them altogether.

To remove useless alders, willows, and other plants which frequently beset lands that furnish no timber, and hardly any valuable crops, though naturally fitted to become rich meadow lands, is a measure as rational and promising of advantage as any that can occupy a husbandman. Rude stones may be blasted, and carried off for the purposes of enclosing or building; and water may be collected in drains for the purpose of irrigation. A few trees at considerable distances do little harm in meadow lands. The levelling process, when it becomes necessary, is commonly the most serious; but, when executed, it seldom fails amply to repay cost and labour.

After the lands, which are situated conveniently for meadows, are separated from the outer pastures in the first place, (if there be hilly or mountainous grounds,) and next from the lands allotted for cultivation by the plough, the next thing to be done is to ascertain what proportion of these meadows is proper for irrigation.

This depends on the wants of the farm, and the chance of a sale for surplus hay; but it must also be regulated by the conveniency of putting on water in season, and by the prospect of labourers to perform the necessary operations, and to cut down and make the produce into hay. A considerable degree of attention must also be given to the climate and to the quality of the water. For the necessary instructions in these particulars, see the articles Agriculture and Irrigation.

The remaining meadow lands fall to be considered as the proper subject of the present article; and its importance may be inferred from these undeniable facts, that a very great extent of lands is left neglected, and unproductive of either timber, grass, or corn, which might, at less expense than is laid out on arable soils, be rendered equally if not more valuable; that such manures might be applied to those as are not wanted for the tillage lands; that a great number of extra stock might then be supported; that the stock might be maintained in better order; and that a considerable addition might thus be made to the manure of the farm-yard, and consequently to the produce and value of the arable lands now in cultivation. Such an object is evidently of great importance, not merely to the occupants of land, and more especially to land proprietors, but also to the public.

Supposing brushwood and other obstructions removed, and the lands intended for meadow to be drained and levelled, or made even on the surface, it would remain to be considered in what way to stock them with useful plants, to apply the proper manure to the soil, and then to make the most advantage of the produce.

As many spots of the intended meadow may be without grass, and other parts may be infested with rush, fern, gall, or other plants considered as weeds, the short and simple way of proceeding is to clear these away by the scythe, close to the ground; and then to sow proper seeds over the whole, particularly in bare spots, covering them with earth compost; by which means the soil will at once be manured, and sown with useful seeds. This operation will succeed either about Lammas or in March; and the field must then be carefully preserved until the plants are grown. A proper degree of subsequent attention will be successful in training up the seeds, and in stocking the lands: there may indeed be many of the original coarse plants; but these, by manure, and by the scythe, will be so improved, as not much to deteriorate the others with which they grow. After two or three years of this attention, and by means of one good dressing on proper seeds, the meadow will be gained. This dressing ought to be ample, and to consist of good earth and lime duly mixed by the spade; or, in case of a high end ridge occurring, it may be saturated with lime by the plough and harrows, and then laid on the meadow.

When the surface is naturally clothed with verdure, but the grass happens to be coarse and poor, a dressing of lime will enrich at once the quality and quantity, and will more amply and certainly repay the farmer, when thus applied to convert neglected lands into meadow, than it can be expected to do when applied to arable soils limed recently or frequently before. Indeed this appears to be now the most profitable way in which lime can be applied, in districts accustomed to the use of it. Marle is even more valuable than lime when thus applied; and the grass that follows is uncommonly rich and good in quality.

At the present moment, when the sale of lime for arable soils is beginning to fall off, a more interesting or profitable measure can hardly be suggested, than to apply it liberally to such coarse neglected lands, as may thus be converted from wastes into meadows.

Various other manures may be so applied; but lime being found in such quantities, that it may be used at pleasure, and water being the legitimate manure for grass, the farmer cannot injure his corn lands by thus enriching his wastes for meadow. Clay ashes also promise to be of great use for the same purpose; and indeed all sorts of ashes are most useful when applied in this manner.

A repetition of manure once in three years has been commonly found sufficient, even when crops of hay were taken; and for pasturage, exclusive of hay, additional manure will seldom be required, unless it be thought proper to top-dress with lime: should hay be taken alternately with pasture, an occasional dressing with ashes or compost once in six years will be found sufficient.

Meadows may be used either in pasture, or their produce as green food cut for stock, or made into hay. Meadow pastures are commonly excellent: In dry soils they are very suitable for stock of any description; in moist lands they raise the size and bone of young cattle above any other pastures: a very important extra benefit arising from them is, that by saving parts of this kind of pasture, the farmer may derive great advantage at seasons when he would otherwise have no resource.

The benefit of cutting the produce of meadows, and of using it for soiling, is also very considerable. In this way stock may be advantageously carried forward, and kept in proper condition at different seasons of the year; the produce of meadows assisting in this plan, and serving to supply the want of green food at the particular period when it is in readiness. For the particulars of this practice, see the article *Soiling*, under that of Agriculture.

But the prominent advantage arising from the produce of meadows is reaped in the crops of hay which may be raised on them. That of dry meadows, called in Scotland lay, ley, or lee hay, is adapted best for horses, young cattle, and sheep. That of damp, soft lands, called bog hay, suits cattle arrived at full size. Nothing can better accommodate the farmer than such excellent supplies of winter and spring food, by which he may be enabled to support his live stock, and to produce them in superior order for the markets. At the same time he is enabled to increase his manure and resources for cultivating his tillage lands; and the produce of his meadows, if carried to market, is a public accommodation for other farmers not possessed of such meadows, or for cottagers and others to support their cows during winter.

In laying down and managing lands as meadows, it is of importance not only to stock them with useful plants, as observed above, but also to extirpate noxious weeds. The latter purpose may be accomplished in part by drains and the scythe, which, in the course of time, subdue rushes, (*juncus conglomeratus*,) and render the coarsest sprett, (*juncus articulatus*,) by means of manuring also, more succulent and useful as grass and hay. Thistles, (*carduus palustris*,) common in damp meadows, may speedily be eradicated by the hand in proper season; and ordinary attention and diligence will soon become effective in subduing noxious weeds of all descriptions. The marsh marygold (*caltha palustris*,) will indeed rise abundantly in water meadows, but not in those which are the subject of this article.

With respect to the most useful plants in meadows not watered, those which follow may be named as prospering best, and proving most useful, either in a dry or a moist soil; viz. on dry soils, where lime or marl have been applied, perennial rye grass (*lolium perenne*,) and white clover (*trifolium repens*) answer particularly well, and the rich and partly aromatic millefoil (*achillea millefolium*) is equal in value to either. Rib-grass, (*plantago lanceolata*,) in all country farms and on dry meadows, answers well to mix among others, and thicken the pile; though, close to the smoke and dust of cities, its broad leaf becomes partly soiled, and the plant is less relished. A proportion of soft meadow grass (*holcus lanatus*) will increase the produce, and extend the period of its being fit for pasture, coming at an early season; and cocksfoot (*dactylis glomerata*) will be found a ready and substantial auxiliary. The seeds of all these are easily gathered, and may also be readily had in the shops, excepting those of millefoil, which, however, deserve to be sought after.

For damp soils the following plants answer best, viz. a similar proportion of perennial rye grass and white clover, together with a mixture of wild red clover, (*trifolium medium*,) common poa, (*poa trivialis*,) soft meadow grass, and scented vernal grass, (*anthoxanthum odoratum*.) These may be sown as above directed, and covered with compost earth.

It is very true that, by individual gentlemen of considerable eminence, lands have been sown down into grass with fewer varieties of seeds, and some have done this by means of one single variety. Peat bogs and soft lands have been turned into meadows, by sowing either the soft meadow grass, or the seeds of timothy, (*phleum pratense*;) and rich muddy soils, intended for ample waterings, have been laid down by planting the fiorin (*agrostis stolonifera*) alone. But as this article is chiefly directed towards natural meadows, and as these, for the most part, are found to be stocked with such varieties as are herein recommended; since it is acknowledged, that such a variety affords a more abundant and more continued supply in the various months of the season; and since the various plants feed at different degrees of depth, and form on the whole a more grateful and profitable crop, it cannot be doubted, and observation fully confirms it, that meadow grasses ought to be mixed.

In case these more select seeds cannot be had, a farmer may venture to sow the seeds that he can collect from hay, of ordinary good quality, made on similar soils in his neighbourhood; and, as meadow grasses require some time in coming to maturity, he may sow among them whatever cheap annual seeds he has, (goose grass for instance,) by which means he will secure a full crop a year sooner than he could otherwise expect one; the earlier seeds coming forward at first, and the others rising among them, and occupying the soil in due time.

The value of meadow lands in a populous district is well known, for the purpose of supplying milk and other necessaries that cannot bear distant carriage, which corn itself can better do; and hence the great importance of such lands in the manufacturing districts of Yorkshire and Lancashire. But, besides this consideration, there are others. For instance, in a high situated country, where corn is an expensive and precarious crop, rich meadows are of great importance; and in a low corn district, where arable soils are in great extent, and meadows are capable of being richly manured, and of yielding various crops of grass for early and latter pasture, when there is no other grass on the common pastures besides hay, the superior value and importance of meadow lands need no illustration.

Instead, then, of adopting the hazardous advice of breaking up the meadow lands for corn, and sowing them out again, it may be laid down as a wise rule, to preserve in meadow those rich grass lands which already pay more rent in that state than similar adjacent soils in tillage; and perhaps there is nothing more wanted in the present state of agriculture, than a practical and correct system of management of meadow land, embracing the proper treatment of such as are already laid down to meadow—the conversion of such waste lands as are proper to be so laid down—the legitimate modes of manuring natural meadows, without encroaching on the manure of the farm yard, which is better adapted for arable soils—and the application of the returns to the best purposes, for the maintenance and improvement of live stock, and for adding to the manures and fertility of tillage lands (K. K.)

MEAN TONE in *Music*, or MEDIUM TONE, is a term which has been differently applied by different writers.

MEAN *Tone* of *Aristoxenus*, Salinus, and many other writers, is the half a major third, or $\frac{1}{2}$ III; it has the ratio $2\div\sqrt{5}$, $=89\frac{1}{2}\Sigma+2f+8\frac{1}{2}m$, $=98.503931\Sigma+2f+8m$: its common log. $=\cdot9515449,9350$: its binary log. $=\cdot1601515$; and its major comma log. $=8\cdot93599$: it is also equal $\frac{1}{2}T+\frac{1}{2}t$, $=T-\frac{1}{2}c$, $=t+\frac{1}{2}c$, $=t+S-\frac{1}{2}T$, $=2\mathscr{f}+4\frac{1}{2}t+3\Sigma$, &c.; and it is the major second of the MEAN TONE *System*, which see.

MEAN *Tone* of *Galileo*, Emerson, &c, is one-sixth of the octave, or $\frac{1}{6}$ VIII; it has the ratio $1\div\sqrt[6]{2}$, $=102\Sigma+2f+8\frac{5}{6}m$, $=101\cdot9986896\Sigma+2f+9m$; its common log. = ·9498283,3406 : its binary log. = ·166666, = T — $\frac{1}{6}$𝔡 ; and it is the second of the ISOTONIC *System.*

MEAN *Tone* of *Sauveur*, has the ratio $\frac{3645}{4006}$, = $\frac{3^6\times5}{2^{12}}$, = 103Σ+2f+9m : its common log. = ·9493375,8468 ; its binary log. = ·168296 ; it is =, S+L, t+𝕮, 2L+c, ✠+2𝕮, and 9 c +2r ; = T — Σ, II — Σ, 2 S — c, and 3 S—𝔣𝔠. On a Listonian organ it may be *tuned* thus above C ; viz. 4 VIII—6V—III, and is the note E`♭♭, or interval DF`♭.

MEAN *Tone* of *Tempered Systems*, has been shewn by Mr. Farey, in the *Phil. Mag.* vol. xxxvi. p. 44. to be in any regular douzeave of the value, $\frac{104\,s-2r}{s}\Sigma+2f+\frac{9u-2t}{u}m$; $\frac{-r}{s}\Sigma+\frac{-t}{u}m$, being the flat temperament of the major fifth. See our article DIESIS.

MEAN *Tone System* of Musical Intervals, or the system of *perfect* Major Thirds, (called also the Vulgar or common temperament,) appears to have been first noticed by Salinus, when hearing the musical performances in Rome, in the first half of the 16th century, and it was some time after published by Zarlino; since which it has been either described or recommended, by Aretinus, Dichelas, Flight, Holder, Rameau, Robison, Smith, Smyth, and several other writers; and it appears to have been long *in general use* by the tuners of organs, notwithstanding the very confident manner in which a numerous class of writers have at various times recommended some other system for the organ. The reason, however, of this preference given to the *Mean Tone* System, by modern *organ* tuners, appears not to have been sufficiently understood until lately; viz. that *the magnitudes of the temperaments* of each and all of the concords, are therein very nearly *in the inverse ratio of the frequency of the use of each* of such concords in organ performances; a fact, for which we are indebted to the learned investigations of Professor *Fisher*, of Yale College in America, which have been published in the first and second numbers of Silliman's "*American Journal of Science*," since our articles in F were printed off; and where, otherwise, we should have given some particulars of one or both of the systems (very nearly coinciding with the mean tone system) which Professor *Fisher* has deduced, from the actual occurrence of the various concords in 1600 organ scores, indiscriminately selected! these, now, we must reserve for our article, See TEMPERAMENT.

In Dr. Smith's Harmonics, 2d edit. plate 20, the *beats* of the mean tone system in 15″ are given; and in the "*English Musical Gazette*," vol. i. p. 69. the beats in 1*m*, for adapting the same to the "metronome," or time-beater of Maelzel: but we shall, on the present occasion, in order to preserve uniformity in our mode of stating each tempered system, and for facilitating comparisons amongst them, extract the Table of Beats which Mr. Farey and Mr. Smyth calculated in 1810, for the Philos. Mag. vol. xxxvi. p. 436. correcting several press errors therein, and adding some columns, viz.

1	2	3			4	5	6	7	8	9	10	11	
c	612	612	12	53	50000	480·0000	——	——	——	——	——	——	
B	552¼	552	11	48	·53499	448 6065	8·3660	53·8099	5·5740	4·1755	0·	6·9675	
B♭	513½	514	10	45	·55902	429·3227	68·1522	0	5·3410	3 9793	80·4716	6·6893	
A	453¾	454	9	39	·59814	401·2438	7·4628	0	4·9886	3·7314	0·	5·2470	
G♯	394	394	8	34	·64000	375·0000	6·9675	45·0000	4 6704	♯23·4212	0·	50·9832	
G	355¼	355	7	31	·66874	358·8838	6·6893	0·	4·4648	3·3422	0·	5·5819	
F♯	295½	296	6	26	·71554	335·4110	6·2470	40·2358	4·1755	3·1194	0·	45·5768	
F	256¾	257	5	22	·74767	320·9972	50·9832	0·	3·9793	2·9916	60·1936	4 9778	
E	197	197	4	17	·80000	300·0000	5·5819	0·	3·7314	2 7870	0·	5·6704	
E♭	158¼	158	3	14	·83593	287·1053	45·5768	0·	♭23·4212	2·6705	53·8099	4·4735	
D	98½	99	2	9	·89443	268·3273	4·9778	0·	3 3422	2·4943	0·	4·1830	
C♯	38¾	39	1	3	·95702	250·7784	4·6704	30·0968	3·1194	2·3352	0·	34·0761	
C	0	0	0	0	1.0000	240·0000	4·4736	0·	2·9916	2·2324	45·0000	3·7314	
Notes.	Artif. Commas.	$\underbrace{\Sigma+f+m}$ Approximate Listonian notes			Lengths of Strings.	Vibrations in 1″ of time.	Flat, 3ds	Sharp, IIIds.	Sharp, 4ths	Flat, Vths	Flat, 6ths.	Sharp, VIths.	
							Beats in 1″ of time.						Totals.
Sums of the Beats of each Concord, and of the totals, in						Mean Tone	220·1484	169·1425	69·7994	57·2800	239·4751	178·1579	934 0033
						Isotonic	217·8068	160·1699	18·2413	13·6659	254·2546	183·1527	847·2912
						Huygen's.	220 0122	168·6611	66·7339	54·6635	240·3551	178.4376	928.8634

Several similar tables having already appeared in our work, it is conceived that any further description thereof is unnecessary, except as to the sums of the beats in the three last lines; those of the Isotonic and Mr. Huygen's system are added, in order to shew to the musical student, the effects which different modes of attempering the douzeave have on the sums and totals of the beats. Respecting the last mentioned system, it will be proper to notice here some errors which occurred in transcribing the table for the press, viz. in the beats of the 4ths, which require correcting as follows: viz. on F♯, 4.0233, on F 3.8480, and on E 3.598 beats.

MEASURES of *Musical Intervals*, see our articles BINARY, EULER'S COMMON and HYPERBOLIC LOGARITHMS, COMMON MEASURES, FAREY'S NOTATION, and LOGARITHMS LOGOMETRIC.

MEASLES. See MEDICINE.

MEASURES.

Measures, in a legal and commercial sense, signify the dimensions of any thing bought, sold, or valued. There are three kinds of measures. 1. *Linear measure*, or that which is used for lines, which have only the dimension of length, such as roads or distances, either on the surface of the earth, or in absolute space. 2. *Square measure*, or that which is used for surfaces which have the dimensions of length and breadth, as in land-measuring, &c. and 3d. *Solid measure*, or that which is used for solid bodies, which have the three dimensions of length, breadth, and thickness, as in the mensuration of timber, the guaging of vessels, &c. See Mensuration.

All measures, whether linear, square, or solid, are deduced from some established standard measure of a lineal kind, either arbitrarily assumed, or related to some invariable distance in nature. Arbitrary standards have till lately been adopted by all nations, and their measures have been deduced from the length of some part of the human body, as, the foot, the cubit, the span, the nail, the ulna or arm, the fathom, the pace, and the inch, or thumb. The modern yard is said to have been adjusted by the arm of Henry I. in 1101; and it has been conjectured that the old French foot, or *pied du roi*, had a similar origin. The natural standards which have been proposed are, 1st, The length of the pendulum that vibrates seconds; 2d. The space described by a heavy body in a second of time; the 3d, the length of a quadrant of a meridian of the globe.

The French are the only people who have adopted a natural standard as the foundation of their system of weights and measures; and, notwithstanding its theoretical elegance, we are persuaded that such an expement upon the habits and customs of a country will never be again repeated but under similar circumstances, where the political reasons for the innovation are far more powerful than the scientific ones. Whenever a nation has resolved to despise and to forget its ancient and venerable institutions, we may then expect that the adoption of a scientific system of weights and measures will be one of its earliest innovations.

The partial abandonment of the new system which we shall presently see took place in France, under the rule of Bonaparte, is a strong proof of the difficulty of rooting out long established prejudices, and will, we trust, be regarded as a warning to other countries, not to tear down, with a rash hand, even those institutions which are allowed on all hands to be defective, and capable of amelioration.

In the present article, which must necessarily be very limited, we shall give an account, 1st, Of the measures of England; 2d, Of the measures of Scotland and Ireland; 3d. Of the new metrical system of the French, and of the change made upon it in 1812; and 4th, A short account of the measures of other nations.

Sect. I. *On English Measures.*

The standards of English weights and measures are kept principally in the Exchequer, from whence standards are committed to public offices, one of the principal of which is Guildhall, and also to individuals who are licensed to size, adjust, and vend weights and measures.

The standards of the English yard are as follow, the length of each of them being given in relation to Mr. Troughton's scale as the standard, according to the determinations of Sir G. Shuckburgh:

	Inches
Original standard kept in the Tower, - -	36.00400
The yard F on the Royal Society's Scale by Graham,	36.00130.
The Exchequer yard of the same scale, - -	35.99530.
General Roy's scale, used in the measurement of a base on Hounslow Heath, - - - -	36.0003
The Royal Society's scale by Bird, - - -	35.9995
Bird's Parliamentary standard of 1758, - -	36.0002

The standard measures kept at the Exchequer for adjusting the corn and beer measures, are, a bushel, a gallon, and a quart, dated 1601, and a pint dated 1602. They were examined in 1819 by Sir George Clerk, Bart. and Dr. Wollaston, and the weight of Thames water which they held, at the temperature of 52°, was found as in the following table. But as a cubic inch of distilled water at 60°, weight 252½ grains, according to Sir G. Shuckburgh, the specific gravity of the water being to that of distilled water, as 1.00068 to 1, and the apparent specific gravity of distilled water in a vessel of brass at 52° being to that of water at 62°, as 1.00046 to 1, it follows that the apparent specific gravity of the water employed was 1.00106, and that an ounce Avoirdupois corresponded to 1.731 cubic inches. In this way Sir George Clerk and Dr. Wollaston obtained the contents of the measures in cubic inches, which they have compared in the table with the more direct measurement of Mr. Bird and Mr. Harris, as reported to the House of Commons in 1750.

	Ounces Avoird.	Cubic Inches.		Cubic Inches in a Gallon, as deduced from each.	Measures of Bird and Harris.
Pint	20.00	34.6 × 8	=	276.9	34.8
Quart	40.35	69.8 × 4	=	279.3	70.0
Gallon	156.25	270.4 =		270.4	271.0
Bushel	1229.85	2128.9 × ⅛	=	266.1	2124.0

These four different values of the gallon, as deduced from the same standard measure, differ widely from one another, and point out the urgent necessity of obtaining more correct standards.

The exchequer standard wine gallon, dated 1707, was found by Sir George Clerk and Dr. Wollaston to contain 133.4 ounces, or 230.9 cubic inches. In 1814 Dr. Wollaston and Mr. Carr found it to contain 230.8 cubic inches, the mean of which is 230.85, while, according to the measurement of 1758, it was 231.2. A duplicate of this measure having the same date is kept at Guildhall.

The three other wine gallons kept at Guildhall were likewise examined by Dr. Wollaston and Mr. Carr; the oldest of them, which seems to be the one measured by Halley and Flamstead in 1688, and said to contain 224 cubic inches, contains 224.4 cubic inches. The wine gallon of 1773, which is daily used for adjusting other measures, appears to have been originally an exact copy of the exchequer gallon, but has been reduced by a bruise, and by the wear of the brim, to 230.0 cubic inches, having lost $\frac{4}{5}$ths of a cubic inch, or $\frac{1}{300}$th of its whole capacity. The wine gallon of 1798 contains 230.8 cubic inches. By a number of experiments the excise wine gallon was found to contain 230.1 cubic inches, having partaken of the progressive deficiency of the Guildhall gallon from which it was derived.

LONG MEASURE.

					French Metres.
3 Barley corns	=	1 Inch	=		0.0254
3 Inches	=	1 Palm	=		0.0762
4 Inches	=	1 Hand	=		0.1016
9 Inches	=	1 Span	=		0.2286
12 Inches	=	1 Foot	=		.3048
3 Feet	=	1 Yard	=		0.9144
6 Feet	=	1 Fathom	=		1.8288
5½ Yards	=	1 Pole or Rood	=		5.0291
40 Poles	=	1 Furlong	=		201.1632
8 Furlongs	=	1 Mile	=		1609.3059
3 Miles	=	1 League	=		4827.9179
63 Geographical 69½ English miles	=	1 Degree	=		11120.7442

CLOTH MEASURE.

2¼ Inches	=	1 Nail	=	0.0571
4 Nails	=	¼ of a yard	=	0.2286
3 Quarters	=	1 Flemish Ell	=	0.6858
4 Quarters	=	1 Yard	=	0.9143
5 Quarters	=	1 English Ell	=	1.1429
6 Quarters	=	1 French Ell	=	1.3715

WINE MEASURE.

				Cubic Inches.		French Litres.
4 Gills	=	1 Pint	=	28.875	=	0.4731
2 Pints	=	1 Quart	=	57.75	=	0.9463
4 Quarts	=	1 Gallon	=	231.	=	3.3735
42 Gallons	=	1 Tierce	=	5.614 *cub. ft.*	=	158.9673
2 Tierces	=	1 Puncheon	=	11.228 do.	=	317.9345
63 Gallons	=	1 Hogshead	=	8.421 do.	=	238.4509
2 Hhds.	=	1 Pipe or Butt	=	16.842 do.	=	476.9018
2 Pipes	=	1 Tun	=	33.684 do.	=	953.8036

N. B. An anker is 9 gallons, and a rundlet 18 gallons.

ALE and BEER MEASURE.

				Cubic Inches.		French Litres.
		1 Pint	=	35.25	=	0.5776
2 Pints	=	1 Quart	=	70.5	=	1.1552
4 Quarts	=	1 Gallon	=	282.	=	4.6208
8 Gallons	=	1 Firk. of Ale	=	1.305 *cub. ft.*	=	36.9669
9 Gallons	=	1 Firk. of Beer	=	1.468 do.	=	41.5872
2 Firkins	=	1 Kilderkin	=	2.937 do.	=	83.1744
2 Kilderkins	=	1 Barrel	=	5.875 do.	=	166.3488
1½ Barrels	=	1 Hogshead	=	8.812 do.	=	249.5232
2 Barrels	=	1 Puncheon	=	10.750 do.	=	332.6876
2 Hogsheads	=	1 Butt	=	17.624 do.	=	499.0464
2 Butts	=	1 Tun	=	35.248 do.	=	908.0928

DRY MEASURE.

				Cubic Inches.		French Litres.
4 Gills	=	1 Pint	=	33.6	=	0.55053
2 Pints	=	1 Quart	=	67.2	=	1.10107
2 Quarts	=	1 Pottle	=	134.4	=	2.20214
2 Pottles	=	1 Gallon	=	268.8	=	4.40428
2 Gallons	=	1 Peck	=	537.6	=	8.80856
4 Pecks	=	1 Bushel	=	2510.42	=	35.23430
4 Bushels	=	1 Coom	=	4.977 *cub. ft.*	=	140.93721
2 Cooms	=	1 Quarter	=	9.954 do.	=	281.87443
5 Quarters	=	1 Wey or Load	=	49.770 do.	=	1409.87216
2 Weys	=	1 Last	=	99.540 do.	=	2818.74432

COAL MEASURE.

4 Pecks	=	1 Bushel
3 Bushels	=	1 Sack
3 Sacks	=	1 Vat
4 Vats	=	1 Chaldron
21 Chaldrons	=	1 Score

N. B. The coal bushel holds 1 Winchester quart more than the Winchester bushel, and is therefore =2150.42 cubic inches + 67.2 =2217.68 cubic inches.

The values in French measures annexed to the preceding Tables, are founded upon the supposition, that the French metre =39.371 inches, and the French litre =61.028 cubic inches; but by adopting General Roy's table as a standard, the value of the French metre will be 39.3694 inches.

Although the subject of weights and measures has repeatedly been under the consideration of the legislature of this country, yet no law has as yet passed for improving and giving uniformity to the system.*

In the year 1814, Sir George Clerk, Bart. brought in a bill for regulating the weights and measures of this country; but after passing the House of Commons, it was, from causes which it is not our business to investigate, lost on the second reading in the House of Lords, in 1816

Notwithstanding this decision, the vast importance of the bill was felt and acknowledged by all classes of the community; and accordingly the Prince Regent appointed Sir Joseph Banks, Bart. Sir George Clerk, Bart. Davies Gilbert, Esq. Dr. Wollaston, Dr. Thomas Young, and Captain Kater, as commissioners, for the purpose of considering how far it was practicable and advisable to establish a more uniform system of weights and measures. These distinguished individuals, after having obtained all the requisite information, submitted to the House of Commons a report, dated 24th June, 1819, of which the following is an abstract.

"I. Upon a deliberate consideration of the whole of the system at present existing, we are impressed with a sense of the great difficulty of effecting any radical changes to so considerable an extent as might in some respects be desirable; and we therefore wish to proceed with great caution in the suggestions which we shall venture to propose.

II. With respect to the actual magnitude of the standards of length, it does not appear to us that there can be any sufficient reason for altering those which are at present generally employed. There is no practical advantage in having a quantity commensurable to any original quantity existing, or which may be imagined to exist in nature, except as affording some little encouragement to its common adoption by neighbouring nations. But it is scarcely possible that the departure from a standard, once universally established in a great country, should not produce much more labour and inconvenience in its internal relations, than it could ever be expected to have in the operations of foreign commerce and correspondence.

III. The subdivisions of weights and measures at present employed in this country, appear to be far more convenient for practical purposes than the decimal scale, which might perhaps be preferred by some persons for making calculations with quantities already determined. But the power of expressing a third, a fourth, and a sixth of a foot in inches, without a fraction, is a peculiar advantage in the duodecimal scale; and for the operations of weighing and of measuring capacities, the continual division by two, renders it practicable to make up any given quantity with the smallest possible number of standard weights or measures, and is far preferable in this respect to any decimal scale. We would therefore recommend, that all the multiples and subdivisions of the standard to be adopted, should retain the same relative proportions to each other as are at present in general use.

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* For a full account of the history of weights and measures in this country, we must refer the reader to Mr. Reynardson's paper in the *Phil. Trans.* 1749; Dr Kelly's *Metrology*, Lond. 1816; and an able report by Dr. Thomas Young, forming Appendix B to the Report of the commissioners in 1819.

IV. We beg leave to recommend, for the legal determination of the standard yard, that which was employed by General Roy in the measurement of a base on Hounslow Heath, as a foundation for the trigonometrical operations that have been carried on by the Ordnance throughout the country, the temperature being supposed to be 62° of Fahrenheit when the scale is employed.

V We propose also, that it should be declared for the purpose of identifying or recovering the length of this standard, in case that it should ever be lost or impaired; that the length of a pendulum vibrating seconds of mean solar time in London, on the level of the sea, and in a vacuum, is 39.1372 inches of this scale; and that the length of the metre employed in France, as the ten millionth part of the quadrantal arc of the meridian, has been found equal to 39.3694 inches.

VI The definitions of measures of capacity are obviously capable of being immediately deduced from their relations to measures of length; but since the readiest practical method of ascertaining the magnitude of any measure of capacity is to weigh the quantity of water which it is capable of containing, it would be advisable, in this instance, to invert the more natural order of proceeding, and to define the measures of capacity rather from the weight of the water which they are capable of containing, than from their solid content in space. It will, therefore, be convenient to begin with the definition of the standard of weight, by declaring that nineteen cubic inches of distilled water, at the temperature of 50°, must weigh exactly 10 ounces troy, or 4800 grains; and that 7000 such grains make a pound avoirdupois, supposing, however, the cubic inches to relate to the measure of a portion of brass adjusted by a standard scale of brass.

VII. The definitions thus established, are not calculated to introduce any variation from the existing standards of length and of weight, which may be considered as already sufficiently well ascertained. But with respect to the measure of capacity, it appears (see p. 568, col. 2) that the legal standards of the highest authority are considerably at variance with each other; the standard gallon, quart, and pint of Queen Elizabeth, which are kept in the Exchequer, having been also apparently employed almost indiscriminately for adjusting the measure both of corn and of beer, between which, however, a difference has gradually crept into the practice of the excise, the ale gallon being understood to contain about 4½ per cent. more than the corn gallon. We think it right to propose, that these measures should again be reduced to their original equality; and, at the same time, on account of the great convenience which would be derived from the facility of determining a gallon and its parts by the operation of weighing a certain quantity of water, amounting to an entire number of pounds and ounces without fractions, we venture strongly to recommend, that the standard ale and corn gallons should contain exactly 10 pounds avoirdupois of distilled water, at 62° of Fahrenheit, being nearly equal to 277.2 cubic inches, and agreeing with the standard pint in the Exchequer, which is found to contain exactly 20 ounces of water.

VIII. We presume that very little inconvenience would be felt by the public from the introduction of this gallon in the place of the customary ale gallon of 282 cubic inches, and of the Winchester corn gallon, directed by a statute of King William to contain 269, and by some later statutes estimated at 272¼ cubic inches; especially when it is considered that the standards by which the quart and pint beer measures used in London are habitually adjusted, do not at present differ in a sensible degree from the standard proposed to be rendered general.

We apprehend also, that the slightest excess of the new bushel above the common corn measure would be of the less importance, as the customary measures employed in the different parts of Great Britain are almost universally larger than the legal Winchester bushel."

The alterations recommended in the preceding Report are marked with so much good sense, and founded on such a proper regard for ancient usages, that we are persuaded they will be gratefully adopted by Parliament and the country. We could scarcely have conceived it possible, indeed, till we read this report, that a uniform system of weights and measures could have been devised, in which there were so few innovations, and in which the innovations that seem to be absolutely necessary were so minute as to escape the notice of ordinary observers.

Sect. II. *On Scotch Measures.*

The standards of weights and measures used in Scotland are preserved in different places. The ell, or ellwand, is kept at Edinburgh; the pint jug at Stirling; the pound at Lanark; and the firlot at Linlithgow.

Linear Measure.

				English Inches.
3 Feet	=	1 Ell	=	$37\frac{1}{5}$
6 Ells	=	1 Fall	=	$223\frac{1}{5}$
24 Ells	=	1 Chain	=	$892\frac{4}{5}$
10 Chains	=	1 Furlong	=	8928
8 Furlongs	=	1 Mile	=	7.1424

Hence 30 Scotch Ells — 31 English Yards, and
80 Scotch Miles — 91 English Miles.

Square Measures.

6 Square Scotch Feet	=	1 Square Ell
36 Square Ells	=	1 Square Fall
40 Square Falls	=	1 Square Rood.
4 Roods	=	1 Acre.

The Scotch Acre = 1 Acre 1 Rood $3\frac{1}{3}$ Perches English, and
48 Scotch Acres = 61 English Acres nearly.

Liquid Measure.

				English Cubic Inches.
4 Gills	=	1 Mutchkin	=	25.851
2 Mutchkins	=	1 Chopin	=	51.702
2 Chopins	=	1 Standard pint	=	103.404
2 Pints	=	1 Quart	=	206.808
4 Quarts	=	1 Gallon	=	827.232
8 Gallons	=	1 Barrel	=	6617.856

Dry Measure.

				English Cubic Inches for Wheat, Pease, Beans, Rye, and White Salt.	*English Cubic Inches for Barley, Oats, and Malt.*
4 Lippies	=	1 Peck	=	549.333	801.381
4 Pecks	=	1 Firlot	=	2197.333	3205.524
4 Firlots	=	1 Boll	=	8789.333	12822.096
16 Bolls	=	1 Chalder	=	140629.333	205154.016

Hence 100 Scotch Bolls of Wheat, Peas, Beans, Rye, and White Salt, } = 51 qrs. 1 Bushel Winchester Measure.

100 Scotch Bolls of Barley, Oats, and Malt. } = 74 qrs. 4 Bushels Winchester Measure

The following is a Table of the provincial measures of Scotland, arranged under the different counties:

Table of Provincial Measures in Scotland.

Counties.	*English cubic inches in the Boll.*	
Aberdeen . . .	10754	for wheat, rye, meal, peas, beans, and seeds;
	14068	for oats, barley, and malt.
Argyle . . .	10218	for wheat, rye, peas, and beans;
	13753	for oats, barley, and malt.
Ayr . . .	8600.68	for wheat, rye, peas, and beans;
	9954	for oats, barley, and malt.
Banff . . .	9265	for wheat, peas, beans, and white salt;
	13476	for oats, barley and malt.
Berwick . . .	12900.52	for all kinds of grain.
Bute and Arran	11512	for wheat, peas, and beans.
	17268	for oats, barley, and malt. For imported grain, the standard measures are employed.
Dumbarton . .	10251	for wheat, meal, peas, and beans;
	13668	for oats, barley, and malt.
Dumfries . .		The Winchester bushel, containing 2150.42 cubic inches, is used for all kinds of grain.
Edinburgh . .		The standard measure is employed for all sorts of grain, which is 8789.32 cubic inches for wheat, rye, peas, beans, and white salt.
	12822	for oats, barley, and malt.
Elgin and Forres	9384	for wheat, rye, peas, and beans;
	13496	for barley;
	16870	for oats.
Fife	9100	for wheat, peas, and beans;
	13236	for oats, barley, and malt.
Forfar . . .	9100	for wheat, peas, and beans. In this county, the boll varies considerably in the different principal towns.
	8893	for wheat, at Brechin and Dundee.
	9384	for wheat, at Arbroath.
	12926	for barley, oats, and malt.
	13442	for barley, at Brechin and Montrose.
	13029	for oats, barley, and malt, at Dundee.
	13236	for oats, barley, and malt, at Forfar.
Haddington . .		The measures in this county, though meant to be standard, are actually about 3 per cent. larger. For the *Standard Measure*, see Edin.
Inverness . . .	10060	for wheat, peas, beans, and rye;
	14077	for barley and malt; but for oats and barley sold for exportation, there is only 4 firlots to the boll.
Kincardine . .	9927	for wheat, peas, and rye;
	13650	for barley and oats.
Kinross . . .	9022	for wheat, peas, and beans;
	13210	for oats, barley, and malt.
Kirkcudbright .	23654	for wheat, rye, peas, and beans,
	23654.62	
Lanark . . .	9257	for wheat;
	13085	for peas and beans;
	13358	for barley and oats.
		At Lanark, and in the upper ward, the boll for wheat, peas, and beans is standard, or 8789.332 cubic inches Winchester; but for oats and barley it is 13236 cubic inches
Linlithgow . .		The standard measure as given for Edinburghshire, is employed for all sorts of grain in this county.
Nairn . . .	10721	for wheat, rye, peas, beans, oat meal, and barley meal;
	14295	for barley;
	17868	for oats.
Peebles . . .	9418	for wheat, rye, peas and beans;
	13394	for oats, barley, and malt.
Perth . . .	9052	for wheat, rye, peas, and beans;
	13356	for oats, barley, and malt.
Renfrew . .	9617	for peas and beans;
	13623	for oats and barley.
		The standard measure as given under Edinburgh is employed for wheat N. B At Greenock and Port-Glasgow all kinds of grain are exported by the Winchester bushel.
Ross and Cromarty		The measure for wheat, rye, peas, and beans, is standard as given for Edinburgh;
	13236	for oats, barley, and malt
Roxb. & Teviotdale	9200	for wheat, peas, and beans;
	13650	for barley and malt.
		At Kelso, the boll for wheat, peas, and beans is equal to 6 Winchester bushels, or 12902.48 cubic inches; and the boll for oats and barley is equal to 7½ Winchester bushels.
Selkirk . . .	9225	for wheat, rye, peas, and beans;
	12925	for oats, barley, and malt.
Stirling and Clackmannan		Though the measures in both counties are intended to be standard, they are in fact considerably higher.
	9513	for wheat, rye, peas, and beans;
	13753	for oats, barley, and malt.
Sutherland . .	10340	for wheat, rye, peas, and beans;
	14077	for oats, barley, and malt.
		The boll at Dornock for oats, barley, and malt, is 14.187 cubic inches.
Wigton . .	17203.36	for wheat, peas, and beans;
	24605.04	for barley, malt, and oats.

SECT. III. *On Irish Measures.*

The Irish measures do not differ very widely from those of England. The Irish foot and yard are the same in both countries; but there are some points of difference in other respects, which will be seen from the following Tables.

LAND MEASURE.

$10\frac{2}{25}$ Inches = 1 Link.
100 Links = 1 Chain.
7 Yards = 1 Perch.
28 Yards = 1 Chain.
10 Sq. Chains = 1 Sq. acre.
121 Irish acres = 196 Eng. acres.

LONG MEASURE.

7 Yards = 1 Perch
2240 Yards = 1 Mile.
$54\frac{7}{28}$ Miles = 1 Deg. Equat.
11 Ir. miles = 14 E. miles.

DRY MEASURE.

				Cubic inches.
2 Pints	=	1 Quart	=	54.4
2 Quarts	=	1 Pottle	=	108.8
2 Pottles	=	1 Gallon	=	217.6
2 Gallons	=	1 Peck	=	435.2
4 Pecks	=	1 Bushel	=	1740.8

DRY MEASURE.

2 Bushels	=	1 Strike	=	3481.6
4 Bushels	=	1 Barrel	=	6963.2
2 Barrels	=	1 Quarter	=	13926.4
4 Quarters	=	1 Chaldron	=	53705.6
5 Quarters	=	1 Wey	=	69632.0
2 Weys	=	1 Last	=	139264.0

LIQUID MEASURE.

				Cubic Inches.
4 Naggins	=	1 Pint	=	27.2
2 Pints	=	1 Quart	=	54.4
2 Quarts	=	1 Pottle	=	108.8
2 Pottles	=	1 Gallon	=	217.6
18 Gallons	=	1 Rundlet	=	3916.8
40 Gallons	=	1 Barrel of Ale	=	8704.0
31½ Gallons	=	1 Barrel of Wine	=	6854.4
42 Gallons	—	1 Tierce or Aume	=	9139.2
63 Gallons	=	1 Hogshead	=	13708.8
84 Gallons	=	1 Puncheon	=	18278.4
2 Hogsheads	=	1 Pipe or Butt	=	27417.6
4 Hogsheads or 125 Galls.	=	1 Tun	=	54835.2

ALE MEASURE.

10 Gallons = 1 Firkin
2 Firkins = 1 Kilderkin
2 Kilderkins = 1 Barrel
8 Barrels = 1 Tun of ale

COAL MEASURE.

	Winchester Galls.
Half Barrel	= 20
Bushel	= 10
Peck	= 2½

SECT. IV. *On the French Measures.*

On the 1st of August, 1793, the National Convention resolved to adopt an uniform system of weights and measures; and, in the year 1795, a new system was established by law, which had been drawn up by the Academy of Sciences, who were entrusted with the prosecution of it by the Constituent Assembly.

The fundamental unit of the metrical system of France is the *metre*, or the *ten millionth* part of the quadrant of the terrestrial meridian, from the equator to the north pole, which passes through Paris. This quadrant was found, by very accurate observations, to be 5130740 toises of six feet each, and therefore the metre is equal to 3 feet 11 lines, and $\frac{296}{1000}$ of the ancient measure of France. From the metre, all other measures of length are derived by decimal multiplication and division, thus,*

Deca-metre is = 10 times the metre
Hecto-metre = 100 times the metre
Kilo-metre = 1000 times the metre
Myria-metre = 10,000 times the metre
By multiplication.

Deci-metre is the 10th part of a metre
Centi-metre 100dth part of a metre
Milli-metre 1000dth part of a metre
By division.

FRENCH LINEAR MEASURE.

	English Feet.	Old French Feet.
Quadrant of the meridian	32809167.	30784440.
Centesimal degree	328091.67	307844.4
Myriametre	32809.167	30784.44
Kilometre	3280.9167	3078.444
Hectometre	328.09167	307.8444
Decametre	32.809167	30.78444
Metre	3.2809167	3.078444

	English Inches.	French lines.
Decimetre - - -	3.9371	44.3295936
Centimetre - - -	0.39371	4.43295936
Milimetre - - -	0.039371	0.443295936

FRENCH SUPERFICIAL MEASURE.

The unit of the superficial or Agrarian measures of France, is the *are*, which is equal to 100 square metres, or a square decametre; and the following Table is obtained from it by decimal multiplication and division, as before:

	English Square Feet.	French Square Feet.
Myriare .	10764414.3923	9476817.46113
Kilare .	1076441.43923	947681.746113
Hectare .	107644.143923	94768.1746113
Decare .	10764.4143923	9476.81746113
Are .	1076.44143923	947.681746113
Deciare .	107.644143923	94.7681746113
Centiare, or square metre	10.7644143923	9:47681746113

	English Square Inches.	French Square Inches.
Square Decimetre -	15.500756	13.646617
		Square Lines
Square Centimetre -	0.15500756	19.651134
Square Millimetre -	0.0015500756	0.19651134

The following subsidiary Table will be found of frequent use.

The ARE = 136466.17144 square French inches.
947.68175 square French feet.
26.32449 square French toises.

The HECTARE = 2632.449 square French toises.
292.494 square perches of Paris.
195.802 square perches for waters and forests.
2.92494 square acres of Paris.
1.95802 square acre for waters and forests.
0.00051 square league.

The CENTIARE = 1364.66174 square French inches.
9.47682 square French feet.
0.26324 square French toises.

MEASURES OF CAPACITY.

The unit, both of liquid and dry measures of capacity, is the *litre*, which is equal to a cubic decimetre. A Paris pint is equal to 0.9313177 litre, or 46.95 cubic inches.

	English Cubic Inches.	Paris Pints.	
Myrialitre -	610280.	10737.47	= 3 muids 26 veltes 1 pint $\frac{3}{4}$
Kilolitre, or cubic metre	61028.0	1073.747	= 37 muids 10 veltes 1 pint $\frac{1}{2}$
Hectolitre -	6102.8	107.3747	=13 veltes 3 pints $\frac{1}{3}$
Decalitre -	610.28	10.73747	=1 pint and $\frac{1}{14}$
Litre, or cubic decimetre	61.028	1.073747	=1 velte 2 pints $\frac{37}{56}$
Decilitre -	6.1028	0.1073747	=$\frac{1}{8}$ litron
Centilitre -	0.61028	0.0107374	

SOLID, OR CUBIC MEASURES.

The unit of the French measures of solidity is the *Stere*, which is equal to a cubic metre, and is therefore the same as the kilometre in a preceding Table. It is used for timber and for fire wood.

	English Cubic Feet.	French Cubic Feet.
Decastere - - -	353.1700	291.738519
Stere, or cubic metres	35.3170	20.1738519
Decistere - - -	3.5317	2.91738519

FRENCH MEASURE OF TIME.

New Division.			Old Division. h.	m.	s.
1 Second		=	0	0	0.864
100 Seconds	= 1 Minute	=	0	1	26.4
100 Minutes	= 1 Hour	=	2	24	0
10 Hours	= 1 Day	=	24	0	0

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* Dr. Thomas Young represents the nomenclature adopted in France as barbarous, and proposes to substitute the more classical words, *Hecato, Chilio,* and *Myrio*, instead of *Hecto, Kilo, and Myria.*

Old Division.		*New Division.* h.	m.	s.
1 Second	=	0	0	1.1574
1 Minute	=	0	69	544
1 Hour	=	1	15	74
1 Day	=	10	0	0

French measure of the Circle.

New Division.			*Old Division.* h.	m.	s.
100 Seconds	= 1 Minute	=	0	0	$32\frac{2}{5}$
100 Minutes	= 1 Degree	=	0	54	0
100 Degrees	= 1 Quadrant	=	0	0	0
400 Degrees	= 1 Circle	=	0	0	0

Old Division.		*New Division.*		
1 Second	=	0°	0′	$3''\frac{7}{81}$
1 Minute	=	0	1	$85\frac{1}{27}$
1 Degree	=	1	11	$11\frac{1}{9}$
1 Quadrant	=	100	0	0
1 Circle	=	500	0	0

After the preceding system had been established and enforced for 16 years, it was found to be pregnant with such evils and inconveniences, that the Imperial government considered it necessary to yield to the wishes of the people, and to establish a modified system, more conformable to their ancient habits. It was therefore decreed on the 28th of March, 1812, that the ancient and respected names of the *toise*, the *ell* or *aune*, the *foot*, the *inch*, and the *bushel*, should be tolerated, but, with the view of preserving the metrical system, that they should represent new measures related to the metrical system in the following manner.

		Metres.			Metres.
Toise	=	2	Aune	=	$1\frac{1}{5}$
Foot	=	$\frac{1}{6}$	Bushel	=	$\frac{1}{8}$ of a Hectolitre
Inch	=	$\frac{1}{72}$			

The *decimal* division of these tolerated measures was likewise abandoned, and the *duodecimal* one enjoined, on the express ground, "that the decimal division, though favourable for calculations, is not equally so for the daily operations of the people, and is not easily comprehended." The French have therefore two systems of measures, the one for philosophers and politicians, and the other for the great mass of the population. We would recommend the careful study of the decree of 1812, to those who wish to establish the decimal division in this country, or to make any serious innovations upon the present system.

Sect. V. *On the Measures of different Nations.*

The following Tables contain all the measures of foreign countries which we can find room to insert.

Table I. *Containing Modern Measures, according to Hutton, Cavallo, Howard, Vega, and others, drawn up by Dr. Thomas Young.*

	Engl.	
Altorf foot -	.775	Hutton.
Amsterdam foot -	.927	H.
	.930	Cavallo.
	.931	Howard.
Amsterdam ell -	2.233	C.
Ancona foot -	1.282	H.
Antwerp foot -	.940	H.
Aquileia foot -	1.128	H.
Arles foot - -	.888	H.
Augsburg foot -	.972	H.
Avignon = Arles.		
Barcelona foot -	.992	H.
Basle foot -	.944	H.
Bavarian foot -	.968	Beigel.
Bergamo foot -	1.431	H.
Berlin foot -	.992	H.
Bern foot -	.962	How.
Besancon foot -	1.015	H.
Bologna foot -	1.244	Hutton.
	1.250	C.
Bourg en Breste foot	1.030	H.
Brabant ell, in Germany	2.268	Vega.
Bremen foot -	.955	H.
Brescia foot -	1 560	H.
Brescian braccio -	2.092	C.
Breslaw foot -	1.125	H.
Bruges foot -	.749	H.
Brussels foot -	.902	H.
	.954	V.
Brussels greater ell	2.278	V.
Brussels lesser ell	2.245	V.
Castilian vara -	2.746	C.
Chamberry foot -	1.107	H.
China mathematical foot	1.127	H.
China imperial foot	1.051	H.
	1.050	C.
Chinese li -	606.	C.
Cologne foot -	.903	H.
Constantinople -	2.195	H.
	1.165	
Copenhagen foot -	1.049	H.
Cracow foot -	1.169	H. V.
Cracow greater ell	2.024	V.
Cracow smaller ell	1.855	V.
Dantzic foot -	.923	Hutton.
Dauphiné foot -	1.119	H.
Delft foot - -	.547	H.
Denmark foot -	1.047	H.
Dijon foot - -	1.030	H.
Dordrecht foot -	.771	H.
Dresden foot .	.929	Wolfe
Dresden ell = 2 feet	1.857	V.
Ferrara foot -	1 317	H.
Florence foot -	.995	H.
Florence braccio -	1.900 1.910	Cavallo.
Franche Comté foot	1.172	H.
Franckfort = Hamburg		H.
Genoa palm -	.812	H.
	.800 .817	C.
Genoa canna -	7.360	C.
Geneva foot -	1.919	H.
Grenoble = Dauphiné		H.
Haarlem foot -	.937	H.
Halle foot .	.977	H.
Hamburgh foot -	.933	H.
Heidelberg foot -	.903	H.
Inspruck foot -	1.101	H.
Leghorn, foot -	.992	H.
Leipzig foot -	1.034	H.
Leipzig ell -	1.833	H.
Leyden foot -	1.023	H.
Leige foot -	.944	H.
Lisbon foot -	.952	H.
Lucca braccio -	1.958	C.
Lyons = Dauphiné		
Madrid foot -	.915	H.
	.918	How.
Madrid vara -	3.263	C.
Maestricht foot -	.916	H.
Malta palm -	.915	H.
Mantua brasso .	1.521	H.
Mantuan braccio = Brescian		C.
Marseilles foot -	.814	H.
Mechlin foot -	.753	H.
Mentz foot -	.988	H.
Milan decimal foot -	.855	H.
Milan aliprand foot	1.426	How
Milanese braccio -	1.725	C.
Modena foot -	2.081	H.
Monaco foot -	.771	H.
Montpellier pan -	.777	H.
Moravian foot -	.971	V.
Moravian ell -	2.594	V.
Moscow foot -	.928	H.
Munich foot -	.947	H.
Naples palm -	.861	Hutton.
	.859	C.
Naples canna -	6.908	C.
Nuremburg town foot	.996	H.
	.997	V.
Nuremburg country foot	.907	H.
Nuremburg artillery foot	.961	V.
Nuremburg ell -	2.166	V.
Padua foot -	1.406	H.
Palermo foot -	.747	H.
Paris foot -	1.066	H.
Paris metre -	3,2808	Report.
Parma foot -	1.869	H.
Parmesan braccio -	2.242	C.
Pavia foot -	1.540	H.
Placentia = Parma		C.
Prague foot -	.987	H.
	.972	V.
Prague ell -	1.948	V.
Provence = Marseilles		
Rhinland foot -	(+1.023	H.)
	1.030	V. Eytelwein.
Riga = Hamburgh		
Roman palm -	.733	H.
Roman foot -	.966	Folkes
Roman deto $\frac{1}{16}$ foot	.0604	F.
Roman oncia $\frac{1}{12}$ foot	.0805	F.
Roman palmo -	.2515	F.
Roman palmo di architettura	.7325	F.
Roman canna di architettura	7 325	F.
Roman staiolo -	4 212	F.
Roman canna dei mercanti	6.5365	F. 8 palms

	Engl.	
Roman braccio dei mercanti	2.7876	Folkes 4 palms
	2.856	C.
Roman braccio di tessitor di tela	2.0868	F.
Roman braccio di architettura	2.561	C.
Rouen — Paris		H.
Russian archine	2.3625	Cavallo.
Russian arschin	2.8333	*Ph. M.* xix.
Russian verschock, $\frac{1}{16}$ archin	.1458	
Savoy = Chamberry		H.
Seville = Barcelona		H.
Seville, Vara	2.760	C.
Sienna foot	1.239	H.
Stettin foot	1.224	H.
Stockholm foot	1.073	H.

	Engl.	
Stockholm foot	.974	Celsius
Strasburg town foot	.956	H.
Strasburg country foot	.960	H
Toledo = Madrid		H.
Trent foot	1.201	H.
Trieste ell for woollens	2.220	H.
Trieste ell for silk	2.107	H.
Turin foot	1.676	H.
	1.681	C.
Turin ras	1.958	C.
Turin trabuco	10.085	C.
Tyrol foot	1.0[illegible]6	V.
Tyroll ell	2.639	V.
Valladolid foot	.908	H.
Venice foot	1.137	H.
	1.140	Ho.
	1.167	C.

	Engl.	
Venice braccio of silk	2.1[illegible]8	C.
Venice ell	2.[illegible]89	V.
Venice braccio of cloth	2.25[illegible]	C.
Verona foot	1.117	H.
Vicenza foot	1.136	H
Vienna foot	1.036	H.
	1.037	Ho.
Vienna ell	2.557	V.
Vienna post mile	24.888	V.
Vienne in Dauphine foot	1.058	H.
Ulm foot	.826	H.
Urbino foot	1.162	H.
Utrecht foot	.741	H.
Warsaw foot	1.169	H.
Wesel = Dordrecht		H.
Zurich foot	.979	H.
	.984	*Ph. M.* viii

TABLE II. *Containing Ancient Measures.*

	English feet.	
Arabian foot	1.095	H.
Babylonian foot	1.144	H.
	1.135	H.
Drusian foot	1.090	H.
Egyptian foot	1.421	H.
Egyptian Stadium	730.8	
Greek foot	1.006 ; 1.007 ; 1.009.	

	English feet.	
Greek Phyleterian foot	1.167	H.
Hebrew foot	1.212	H.
Hebrew sacred cubit	2.002	H.
Hebrew great cubit = 6 common cubits		H.
Macedonian foot	1.160	H.
Natural foot	.814	H.

	English feet.	
Ptolemaic = Greek foot		H.
Roman foot	.965 ; .966 ; .967 ; .9672 ; .9681 ; .9696 ; .970.	
Roman mile of Pliny	4840.5 English feet.	
Roman mile of Strabo	4905.	
Sicilian foot of Archimedes	.730	H.

TABLE III. *Itinerary Measures of different Nations.*

	English yards.
Arabian mile	2148
Bohemian mile	10137
Brabant mile	6082
Burgundy mile	6183
Chinese lis	629
Danish mile	8244
English mile	1760
English mile, Geog.	2025
Flemish mile	6869
French Artificial Leagues	4860
French Marine Leagues	6075
French Legal Leagues of 2000 toises	4263
German Miles, Geog.	8100

	English yards.
German miles, Long,	101[illegible]6
German miles, short,	68[illegible]9
Hamburgh mile	8244
Hanoverian mile	11559
Hesse mile	10547
Dutch mile	6395
Hungarian mile	9113
Irish mile	3038
Italian mile	2025
Lithuanian mile	9781
Oldenburg mile	10820
Poland mile, Short,	6075
Poland mile, Long,	8101
Portuguese Legoas	6760

	English yards.
Prussian mile	8468
Roman mile, Ancient,	1612
Roman mile, Modern,	2025
Russian versts	1167
Saxon miles	9905
Scotch miles	1984
Silesian miles	7[illegible]83
Spanish leguas, Common,	7416
Spanish leguas, Legal,	4635
Swabian miles	10126
Swedish miles	11700
Swiss miles	9153
Turkey berries	1826
Westphalian miles	12151

For farther information on the subject of Measures, See Bernardus, *De Pond et Mens.* Oxf. 1685 ; Cassini, *Mem. Acad. Par* 1702, 13 Delisle, *Id.* 1714, 175. Onsen Bray, *Id.* 1739, 51. Folkes, *Phil. Trans.* 1736, 262. Barlow. *Id.* 1740, 447. *Id.* 1742, 185. *Id* 1743, 541. Raper. *Id.* 1760, 774. Gray, *Edin. Essays*, I. 200 Christiani *del Misure*, Ven. 1760 Paucton's *Metrologie*. 1780. Pictet. *Bibl. Brit.* No. 148. *Nich. Journ.* I. 193, 382. III. 97 IV 163. *Phil. Mag* I 245 XII. 208. Cavallo, *Nat Phil.* vol. iv. Hutton's *Recreations*. I 434. Kelly's *Metrology*, Lond. 1816. Kelly's *Universal Cambist* Dr Thomas Young's *Nat. Phil.* vol. ii. p. 147 &c Rosaz *Nouveaux poids et Mesures tolerés dans l'empire Francois.* Lyons, 1812.

MEATH, a maritime county in Ireland, in the province of Leinster, is bounded on the north by Cavan and Louth; on the east by the Irish Channel and the county of Dublin; on the south by the same county and Kildare, and on the west by Longford and Westmeath. From Castle Jordan to Maiden Tower, its length is nearly 35 miles, and from Ross to Clonce, 29 miles: it is nearly circular in its form. Its area comprises 5[illegible]2 square miles, or 327,900 acres; it is divided into 12 baronies, and 147 parishes. It is intersected by the Boyne, which forms a natural division into the south-east and north-west parts: the former is known under the appellation of Dunshauglin; and the latter under that of Kells. In Dunshauglin, are the baronies of Duleck, upper and lower; Skreene; Ratoath; Dunboyne; Deece, upper and lower; and Moyfenra, upper and lower: in the district of Kells, there are the baronies of Slaine, upper and lower; Morgallean, Kells, upper and lower; Dernifere; Lune; and Navan, upper and lower. The name of Meath, (a word which signifies, in the Irish language, a plain or level,) is very appropriately given to this county, as it in general consists of flat, rich pasture land, seldom diversified with hill or dale, and with very few mountains or bogs. The soil is in general a rich fertile loam, on limestone, gravel or rock; in some parts, according to Mr. Wakefield, it is the richest loam he ever saw turned up by the plough. The climate is cold. The principal river is the Boyne, which rises in Kildare, and enters Meath near Clonard; thence it pursues its course through Trim to Navan, where being joined by the Blackwater river, their united streams flow gently on by Slaine to Drogheda, below which it falls into the sea; its course is nearly 50 miles, and it is increased by the Athboy, the Mannock, and other rivers beside the Blackwater; its banks are richly decorated with the ruins of ancient abbies and castles; but its general character is dull, flowing through a flat country; its appearance, however, in consequence of the numerous aquatic plants with which it abounds, is rather picturesque, and is said to resemble some of the subjects selected by the Dutch and Flemish painters for the subject of their pencils. Nearly opposite to Slaine Castle, lofty and perpendicular rocks succeed to tame and sedgy banks: the strata of some of these rocks are singularly disposed in the form of gothic arches. It is navigable for ships of considerable size as far as Drogheda, and by means of cuts, or rather a canal, barges may proceed to Navan. The Athboy, which rises in the barony of Dernifere, falls into the Boyne at Athboy. The Blackwater rises in Cavan, enters Meath in the barony of Kells, and joins the Boyne at Navan. The Navray rises near Navan, and after passing Duleck falls into the sea; the valley through which it flows is very picturesque and luxuriant. The county of Meath has but four miles of sea-coast, and no port; Drogheda, though situated on both sides of the Boyne, being considered in Louth.

There is little native wood in this county, but numerous and extensive plantations. From the nature of the soil and surface, it cannot be expected to contain many minerals. Potter's clay of an inferior quality is found in the barony of Morgallion; garden pots, tiles, &c. are made of it. At Ardbracchan there is an excellent limestone quarry, the strata extends from this place to the Blackwater, and are horizontal and of various degrees of thickness, from four inches to two feet. Columns have been raised 9 and 10 feet long. The stone, at first, is white, afterwards becomes greyish, and is susceptible of a fine polish. The quarrying of it is attended with great expense, in consequence of the flowing in of the water. The quarry appears to have been wrought as early as the beginning of the 16th century. A bed of excellent copper is wrought at Walter's Town; it extends north-east to the river Boyne.

There are some very extensive estates in Meath; that of the Marquis of Lansdown comprises 60,000 acres, let on perpetuity leases: The fee of Meath is chiefly absentee property. The average rent of the green acres is estimated by Mr. Wakefield at 2*l.* 10*s.* The agriculture pursued principally consists in grazing; and Meath is considered the best grazing county in the east of Ireland; it is, however, the fattening, not the rearing of cattle, to which the Meath graziers chiefly devote their attention. The cattle are bought at the fairs of Connaught and Munster, and are fattened for the Dublin market. Many farmers fatten from 300 to 500 cows in a season—that is, between May and September; besides bullocks and sheep. There are but few dairies of any great extent in this county, nor is the butter made in them much esteemed. The principal dairy farms are in the baronies of Dunboyne and Ratoath: the landlord supplies the cows, horses, and land; and the tenant the labour and utensils; cream only is churned. In other parts, ten shillings a month for each cow is paid to the landlord; few calves are reared. Some excellent specimens of the long horned English breed of cattle are kept in Meath. There are some large flocks of sheep, which, like the cattle, are principally bought at the fair of Ballinasloe in Galway: a considerable number of lambs are reared for the market of the metropolis. Every farmer who occupies 100 acres, breeds a few horses; they are of a bad sort, and are miserably managed. From the mouth of the Boyne to that of the Nanny, there is an extensive rabbit warren, which brings in 300*l.* per annum, on ground that is not worth one shilling an acre: The skins and flesh are sold in Dublin; the former is the most valuable.

In consequence of the high price of corn, there is more land under the plough in Meath at present than there was some years ago; but the tillage in general is very bad. The arable farms run from 100 to 300 acres; and in hiring and stocking these farms, they have scarcely any money, but horses, ploughs, &c.; the labour is supplied by letting land for potatoes; and the seed is paid from the subsequent crop. Six oxen and horses are often seen in the plough, three abreast; the plough and other implements very rude and imperfect; rollers are little known, and harrows used only at seed time. The usual rotation is fallow, very badly made, wheat, oats, oats again, weeds and potatoes. Barley and flax are also cultivated on the banks of the Nanny water; many white pease are grown, instead of a fallow; and about Kilbrue, some beans are grown. Clover, turnips, cabbages, &c. have been introduced, but they do not extend, and where cultivated, it is in a most slovenly and unprofitable manner. Yet there is great encouragement to good arable husbandry, as Drogheda is the largest corn market in the kingdom. There is also great facility in this county for converting the wheat into flour, as the flour mills are numerous, particularly on the Blackwater and the Boyne. One mill can grind above 2400 stone of flour in a day; the machinery in this mill is so contrived as to render the water almost the sole engine in the work; there are several other mills that grind 15,000, and 10,000 barrels each, per annum.

The linen manufacture of the north-east of Ireland extends into this county; but it is principally confined to sacking, dowlas, and coarse linen; the manufacture of sacking is chiefly carried on at Navan; the finest linen is made at Kells. Some paper and cotton is also made in this county but, on the whole, its manufactures are very trifling, and give employment to a very small proportion of its population. The principal towns in Meath are Trim, the county town, Athboy, Navan, and Kells. It contains 4000 freeholders; the number registered are 1584, 40*s.* freeholders; 69 of 20*l.* and 537 of 50*l.* and upwards. It returns two members to Parliament. It is in the province of Armagh, and Diocese of Meath. The Bishop of Meath takes precedency of all the bishops of Ireland, Meath having formerly been an archbishopric. There are 224 parishes in the disocese, 71 of which are in the gift of the bishop, 81 in that of the crown; 37 belonging to laymen, and 35 are inappropriate. The catholics in Meath are computed to be to the protestants as 40 to 1; with the exceptions of Kerry and Galway, there are more catholic proprietors in it than in any other in Ireland; most of the leaseholds belong also to catholics. In the year 1792, there were 22,468 houses, and 112,400 inhabitants; taking the area at 512 square miles, this gives 43.88 inhabitants to a square mile; and taking the number of acres to be 327,900, there will be 14.6 acres to a house. Although Meath, compared with most other counties in Ireland, may justly be considered as improved, and is superior to nearly all the other counties in richness of soil, yet the peasantry, and even the generality of the farmers, are poor, and very little advanced in the scale of society. The houses, even of those farmers who rent from 50 to 150 acres, are in general only one story high, built of the clay on which they stand; and the floor commonly sunk 6 or 8 inches below the surface: their straw beds are in most instances placed on the bare floor. Round the house, in all directions, is most abominable filth: from these circumstances, and the windows being little better than coopholes to admit light enough to do their business, it may be well conceived that the inhabitants are unhealthy. The cottages of the peasantry, except of those who are attached to the richer farmers, are even worse than the houses we have described. The rent of a cabin is 40*s.* with a potatoe garden; if a cow is kept, 40*s.* more.

Of the antiquities in Meath, the most deserving of notice is the Mount at New Grange: it was discovered in the year 1699. In outward appearance it resembles the tumuli so frequent in Wiltshire and Dorsetshire; but it differs from them, by containing a subterraneous temple, apparently of very great antiquity. The temple is an octagon, 20 feet high, and 17 of superficial area: it is formed of the rudest materials. There are three recesses, in each of which there is a large stone vase. The area and the purposes of this cave are equally unknown. There are two round towers in this county, over the keystone of the door of one of which, is the figure of our Saviour on the cross,—an evident proof that these buildings are of Christain origin. Thompson's *Statistical Account of Meath*; Wakefield's *Ireland*; Beaufort's *Memoir of a Map of Ireland*. W. S.

MEATH, WEST. See WESTMEATH.

MECCA, the principal city of Arabia Felix, is situated about 13 leagues east of the Red Sea, and 70 south from Medina. It was known to the Greeks by the name of Macoraba, and is called by the Mussulmans Omm-Alcora, or "Mother of Cities," because it was the birth-place of Mahomet. It is about two miles long, from north to south, and one in breadth. It stands in a barren plain, surrounded by mountains, where the soil is rocky, the water brackish, the pastures distant, and every circumstance unfavourable for the support of a large population. It had begun, however, at an early period to attain a considerable degree of prosperity under its rulers the Koreishites, the most distinguished of the Arab tribes. Perceiving themselves excluded by their position from the pursuits of agriculture, they turned their attention to those of trade; and by the sea-port of Jidda, about 40 miles distant, received articles from Abyssinia, which they conveyed across the peninsula to Geriha, or Kalif, in the province of Bakrein, where the precious articles of the Persian Gulf were purchased, and floated down to the mouth of the Euphrates. They sent caravans to Yemen in winter, and to Syria in summer; brought corn from Bostra and Damascus, and aromatics from Saana and Merab, Oman and Aden. But it was in consequence of its being the birth-place of Mahomet, and the resort of the Moslem pilgrims, that it increased so much in celebrity and extent, as to have contained at one period not less than 100,000 inhabitants. It contains the three holiest things in the Mahommedan world, the well Zemzem, the Caaba, and the Black Stone. Zemzem is believed by the followers of Mahomet to be the identical spring, which gushed forth in the wildersess for the relief of Hagar and Ishmael; and marvellous efficacy is ascribed to its waters, in giving health to the sick, imparting extraordinary strength of memory, and purifying from the effects of sin. The Caaba or temple of Mecca is of great antiquity; and is supposed to have existed, in some ruder form, above 700 years before the birth of Mahomet. It was then a kind of pantheon, in which the Arabs had placed above 360 idols of men and animals; but is now a spacious portico or piazza, adorned with cupolas and minarets. In the centre of the area stands the Caaba, the most highly venerated part of the building, which is a quadrilateral tower, of which the sides and angles are unequal, but the irregularity is not very apparent, in consequence of its being covered with a black cloth, which is annually renewed by the Turkish Sultan. It is about 34 feet high, and 37 long in the front. It has a double roof, supported by three octagonal pillars of aloe-wood; and is furnished with a golden spout, to carry off the rain water from the roof. According to the Mahommedan legend, this temple was built by Abraham; but the stones (of which every mountain in the world contributed some) came ready fitted for the place they were to occupy. The principal wonder of the place is a black stone at the south-east corner, raised about forty-two inches above the surface, and bordered all round with a large plate of silver, about a foot in breadth, except a semicircle of eight inches in diameter at the angle. According to one tradition, this stone fell from heaven during the life of Adam, and was restored to Paradise at the time of the deluge, but was brought to Abraham at the building of the Caaba. According to another account, this stone, having come along with the rest, but being too slow in looking for its place, the building was completed without it; and while lamenting its misfortune, Abraham, moved with compassion, consoled it by the assurance, that it should one day be held in higher veneration than all the rest. It was appointed, therefore, to receive the kisses of the pilgrims; by which, or by the touch of an impure woman, or, as others say, by the sins of the children of Adam, its colour has been changed from white to black. It is, by Ali Bey's account, a fragment of volcanic basalt, sprinkled throughout its circumference with small pointed coloured crystals, and varied with red feldspath upon a dark black ground like coal, except one of its protuberances, which is a little reddish. It is now generally considered to be a meteoric stone. See *Edin. Philosoph. Journal*, No. II. vol. I. p. 224.

The ancient worship of these objects among the idolaters consisted in casting away most of their clothing upon arriving at the precincts of the temple; going round the Caaba seven times, and seven times kissing the black stone; prostrating themselves the same number of times before certain idols in the adjacent mountains; casting stones, sacrificing sheep, and burying their hair and nails in the valley of Mina. These superstitions Mahomet found it impossible to repress; and at length not only consented to permit, but condescended to enjoin them as the most meritorious of all observances. It is, indeed, allowed to the weaker sex, and persons in official stations which they cannot desert, to perform this essential duty by a friend as their proxy. As soon as these devotees arrive at the consecrated district of Mecca, they perform a general ablution with water and sand; repeat a prayer, after stripping off their garments; and put on the sacred habit of colourless woollen cloth, with sandals, which only defend the soles of their feet. They are now devoted to spiritual meditation, and must not even remove any vermin from their bodies. After reaching the city of Mecca, they encircle the Caaba seven times, like their pagan predecessors; repeat certain prayers; drink copiously of the well Zemzem; and kiss with all their ardour the sacred black stone. On the first and second of the three days, (the period for which the Caaba is open every six weeks,) the men and women offer their devotions alternately; and on the last day the scheriff of Mecca, the chiefs of the tribes, and the illustrious strangers present in the city, proceed to wash and sweep the temple. The foul water is caught and drunk by the multitude; the besoms of palm leaves are treasured up as precious relics; and the black cloth which surrounds the door and bottom of the building is cut off and divided among the pilgrims. The next part of the duty is to visit the mountain of Arafal, for the offering up of various prayers at certain times and places; and thence to Mina, where every individual must cast a few small stones (always an uneven number) at the devil's house there, to shew their detestation of the owner. A sacrifice is finally made of a goat, camel, or cow, in commemoration of Abraham's willingness to offer up his son; and after spending three days in this valley, the pilgrims return to Mecca previous to their departure to their respective countries. As they are all allowed to trade on this pilgrimage, the holy city is crowded, on these occasions, with such merchandize of every country as is most easy of carriage, and best adapted for sale; and, in former times, the fair of Mecca was accounted the greatest on the face of the earth. The present commerce, which has so greatly diminished, consists chiefly of the productions and manufactures of India; muslins and chintzes from Bengal and the Decan; shawls from Cashmeer; pepper from Malabar; diamonds from Golconda; pearls from Kilkau; cinnamon from Ceylon; and spices from the Moluccas.

The pilgrims and their traffic form at present the entire support of the city of Mecca; and even with all the advantages which it derives from these numerous visitors, this metropolis of Islamism is represented, by the more recent accounts, as fast sinking into ruin. A great part of the suburbs is in a state of decay, and two-thirds of the remaining houses are uninhabited. The population, which is said to have at one period, amounted to 100,000 souls, does not now exceed 18,000. The contributions of the pilgrims have in a great measure ceased, and their number is annually diminishing, partly from the prevalence of the Wachabees, and also from the decay of Mahommedan zeal. The ancient splendour of the city is still apparent in the beauty of its buildings, which are said to unite with the Arabic a considerable mixture of the Persian and Indian style; but the genius of the people seems to have fled with their prosperity, and in no Mussulman city are the common mechanical arts at so low an ebb. There is not a man to be found in it who can make a lock, a key, or a screw. The only articles which they manufacture are shoes made of wood, or of untanned leather, and all other kinds are brought from Constantinople or Egypt. The very language, once the standard of Arabic elegance, is so corrupted, both in its written and spoken state, by the admixture of foreign terms, and the prevailing ignorance of the inhabitants, that the koran is almost unintelligible to the citizens; and the copies of the sacred book made in the city are written so badly and erroneously, that they are scarcely fit for use. The whole manners and dispositions of the people have become equally degraded; and, according to the descriptions by Ali Bey, the Moorish traveller, their very physical constitution is deteriorated. The men, he declares, are little better than walking skeletons; with large sunken eyes; slender noses; cheeks hollow to the bones; legs and arms absolutely shrivelled up; ribs, veins, and nerves, in no better state; their skin like a parchment stretched over the bones; and their whole frame so wasted, as actually to resemble anatomical models: while they are melancholy in their minds, irritable in their temper, and, of all Mussulmans, the most tyrannical to their slaves. The women are more free and licentious in their manners than in any Mahommedan country; while their personal appearance, besides corresponding with those of the men, is rendered still more forbidding, by the practice of staining their teeth and cheeks with yellow; their lips, feet, and hands with a red-tile colour; and their whole skin with daubs of black, blue, yellow, and indelible figures. See Gibbon's *History of the Fall of the Roman Empire*; Ali Bey's *Travels*; Mill's *History of Mahommedanism*; and the articles CAABA, and METEORIC STONES. (*q*)

MECHANICS.

THE term *Mechanics*, derived from the Greek *μηχανη*, *a machine*, has been employed to denote that branch of natural philosophy which treats of the laws of the equilibrium, and motion of solid bodies, of the forces by which bodies may be made to act on one another, and on the means of employing them so as to overcome other forces that are more powerful. The signification of the term *mechanics* has been extended by some late writers of high authority so as to embrace the abstract laws of motion, and the equilibrium of all bodies, whether solid, fluid, or aeriform; and hence it has been made to include Dynamics, Hydrodynamics, and Pneumatics.

HISTORY.

We can scarcely conceive a state of society so rude as to have been entirely destitute of some of those mechanical resources, which seem to be absolutely necessary for supplying the very earliest of our wants. In detaching a stone from the ground, and in subsequently raising and removing it for the purpose of erecting a habitation, the savage could scarcely fail, under the influence of natural instinct, to employ some means that involved the principle of the lever. By placing a bar of wood below its base, he would soon discover the enormous power of this simple instrument, when its extremity was a fulcrum, and would speedily perceive the advantage of applying the extremity itself to the weight, and placing near it an artificial support or fulcrum. When the mass of stone was thus detached from the earth, the lever would furnish him with the means of removing it to the spot where it was to be employed; but in elevating it to a height, a knowledge of the inclined plane would soon present itself. He would speedily find that the stone was more easily carried on by the lever, or rolled forward by his hands, when the ascent was gentle; and hence he would be led to the practicability of raising large masses to any height, by carrying them up an inclined plane of earth, having its length corresponding to the required altitude. If the mass was at the bottom of a pillar to the top of which it was to be elevated, then he would be compelled to make the inclined plane ascend like a spiral round the pillar, and would thus be led to the construction of the screw. In cleaving wood for his fire the wedge could not fail to suggest itself; and in proportion as the wants of man became more numerous, his resources would likewise increase, and he would soon obtain a high degree of practical information, on the construction and application of the mechanical powers, either when used singly, or in a state of combination.

There can be no doubts that the military engines of the Greeks and Romans, such as the catapultæ and balistæ, which involve the principles of compound machinery, were used long before any attempt was made to explain the simplest principles of mechanical equilibrium; and in the colossal remains of Egyptian architecture we perceive masses of stone elevated to heights which would try, if not baffle, the ingenuity of the most skilful engineer of modern times. The recent discovery, however, that the great Andro-Sphinx is cut out of the solid rock on which it rests, (See *Edinburgh Philosophical Journal*, *No.* I. p. 94,) has diminished the wonder with which the mechanic used to survey the stupendous monuments of Egyptian vanity.

It appears from the writings of Vitruvius, that the ancients had, from time immemorial, made use of the same machines for raising and transporting weights which are in use at the present day, such as capstains, pulleys, cranes, and inclined planes. When Ctesiphon built the temple of Ephesus, he fixed pivots in the ends of each of the massy columns, and thus rolled them from the quarry to the temple by the aid of oxen. In like manner, his son Metageus transported the immense stones which were to form the architraves, by fixing them between two wheels placed as near each other as possible.

Aristotle appears to have been the first who attempted to study the theory of mechanics. His *Questiones Mechanicæ* are filled with obscure, and even ridiculous reasonings respecting the doctrine of motion, and the nature of mechanical equilibrium. He maintained that the equilibrium of unequal weights in the lever or balance with unequal arms, had its origin in the marvellous properties of the circle. In his 28th mechanical question, he has made some unsatisfactory observations on the difference between impulse and pressure. Notwithstanding these errors and obscurities, however, Aristotle, (*Phys* lib. I. cap *ult*) had the merit of discovering the fundamental principle in mechanics, that if two powers move with velocities reciprocally proportional, they will exert equal actions; but he did not see the extensive application of this principle, and it was left to Descartes to make it the foundation of his system of mechanics.

Notwithstanding the few slender contributions made by his predecessors, Archimedes has always been considered as the true founder of the science of mechanics. In his treatise entitled *Isoporrica*, or *De Equiponderantibus*, he has given a complete demonstration of the fundamental property of the lever. Taking it for granted that in a balance with equal arms, the weights that are in equilibrio are necessarily equal, he shows that if one of the arms is increased, the weight which is applied to it must be diminished in the same proportion; and hence he concludes, that the weight suspended at the unequal arms of a balance, and in equilibrio, will be reciprocally proportional to the length of the arms to which they are applied. This important result naturally led him to new speculations respecting the centre of gravity of different figures. Considering that the two weights of his balance exerted the same pressure on the fulcrum as if they had immediately rested upon it, he supposed the sum of these weights to be combined with a third, and the three weights with a fourth, &c. and was thus led to the general principle, that in every system of small bodies, or in every large body considered as a system of small ones, there is a general centre of presure, which he called the *Centre of Gravity*. In the application of the principle to particular cases, he determined the centre of gravity in plain surfaces, bounded by a parallelogram, a triangle, a trapezium and a parabola; and the method which he employed in determining that of a parabolic area, shows that it was not the difficulty of the subject that prevented him from extending his principle to more complex cases. The theory of the inclined plane, the pulley and the screw, which was first published in the 8th book of Pappus's mathematical collections, has likewise been ascribed to Archimedes, and the honour of forty mechanical inventions has been conferred upon him by the ancients. We hope that his invention for moving the earth was not reckoned among the number; and we are disposed to think that the ostentatious speech to King Hiero, Δὸς πȣ στῶ και τον κοσμον κινησω, "Give me a place to stand upon, and I will move the Earth," which has been ascribed to Archimedes, was only the invention of his extravagant admirers. The child who stamps upon the ground with his foot might boast of having actually done all that the philosopher proposed to accomplish; for if Archimedes had received the place to stand upon which he desired, and had also obtained what was equally indispensable, a theoretical fulcrum, and a theoretical lever, and in addition to all this, the power of moving with the velocity of a cannon ball, he would have shifted the earth only the 27th millionth part of an inch in a million of years, a quantity which would not have been appreciable by the eye of his royal master.

If we can place any credit in the narrative of Plutarch, Archimedes had the singular fortune of turning his mechanical genius to the most important purposes. When the Roman engineer, Appius, threatened to overturn the walls of Syracuse, by military engines of unusual power, Archimedes is said to have counteracted their influence by machinery of superior power, and to have thus retarded the capture of his native city.

Macines for bruising grain were no doubt invented as soon as they became an object of necessity. The mectar appears to have been the earliest instrument that was used for this purpose; and when a handle was added to the pestle, to assist in driving it round, it was converted into a hand-mill (*mola versatilis*, or *manuaria*.) This simple machine was afterwards driven by bondsmen, around whose necks was placed a circular piece of wood, to prevent them from putting their hands to their mouths, or eating the meal. In process of time, shafts were added for yoking cattle, and the *Molæ jumentariæ* were constructed. Two mill-stones, the lowermost of which was fixed, and the upper moveable, were employed from the very origin of the Roman republic; and the remains of stones of this kind made by the Romans have been found in Yorkshire. (See *Philosophical Transactions*, *No.* 282, *p.* 1285) Water-mills appear to have been introduced in the time of Mithridates, Julius Cæsar, and Cicero. Strabo informs us, that there was a water-mill near the residence of Mithridates; and we learn from Pomponius Sabinus, that the first mill seen at Rome was erected on the Tiber, a little before the time of Augustus. That they existed in the time of Augustus, is obvious from the description given of them by Vitruvius, and the Epigram of Antipater,* who is supposed to have lived in the time of Cicero. But though mills driven by water were introduced at this early period, yet the water-mills did not appear till the time of Honorius and Arcadius. They were erected on three canals, which conveyed water to the city, and the greater number of them lay under Mount Janiculum. When the Goths besieged Rome in 536, and stopped the large acqueduct, and consequently the mills, Belisarius appears to have constructed, for the first time, floating mills upon the Tiber. Mills driven by the tide existed at Venice in the year 1046, or at least in 1078.

Although Pomponius Sabinus affirms that the Romans had windmills, yet, from the silence of Vitruvius, Seneca, and Chrysostom, who have spoken of the advantages of the wind, we cannot adopt this opinion. Other authors have maintained that they were used in France in the sixth century; while a third class is of opinion, that they were brought into Europe by the crusaders. In the twelfth century, however, they were in use both in France and England; and when they began to be more common, Pope Celestine III. determined that the tithes of them belonged to the clergy†. Saw mills appear to have existed at Augsburgh so early as 1322.‡

Although practical mechanics, or the knowledge of machinery, had made considerable progress before the 16th century, yet the theory of this important science had not advanced a single step since the time of Aristotle. The *Questiones Mechanicæ* were illustrated by commentators as ignorant as their master, and the successive labours of Leonicus, Thomæus, Piccolomini, Bernardus Baldi Monantheuil Guevara, P. Blancanus, and Septalius, obscured rather than illustrated the doctrines of mechanics.

In his treatise, *de Ponderibus et Mensuris*, Cardan attempted to ascertain the force necessary for supporting a weight upon an inclined plane; and from the consideration that the force was nothing when the inclination of the plane was nothing, and that the force was equal to the weight of the body when the inclination was 90°, he concludes that the force is proportional to the angle of inclination. Had he recollected that the sine of the inclination was nothing when the plane was horizontal, and equal to radius when it was vertical, he could not fail to have perceived, that the force which he sought was proportional to the sine of the inclination.

It was a question much discussed at this period, whether or not a balance, with equal arms and equal weights would preserve its horizontal position when once put out of it. Jordanus Nemorarius, a mathematician of the 13th century, had decided in his book, *De Ponderositate*, that the balance could preserve its horizontality, and Cardan, Tartalea, and others, adopted the same opinion. They made no distinction, however, between the case when the directions were parallel, and that in which they were convergent; for, in the first case, the balance, would remain on a level, and in the second, its inclination would increase till it became vertical. Guido Ubaldi, who was correct in showing that, in the case of parallel directions, the balance would keep the inclined position, erroneously attributed the same property to the case of converging directions.

The Marquis Guido Ubaldi, descended of the illustrious house of Dei Monte, had the honour of being the first modern author who treated the subject of mechanics with any degree of success. He was the pupil of Commandin, and spent the greater part of his life in his chateau of Monte Baroccio, wholly devoted to the study of philosophy. His mechanical writings are entitled *Mechanicarum Libri sex ;—In Archimedem de Equiponderantibus Paraphrasis ;* and a posthumous treatise, *De Cochlea*, published by his son in 1616. In imitation of Pappus, and the ancient mechanicians, he reduces all machines to the lever; and he applies this method very successfully to several of the mechanical powers, and, among others, to pulleys, of which he has examined various combinations. In his treatise, *De Cochlea*, he gives a full account of Archimedes's screw, the consideration of which belongs to a former article.

The subject of the motion of projectiles began about this time to attract the notice of philosophers. Daniel Santbech founded a theory of artillery on the ridiculous supposition, that a cannon ball described a straight line till its motion was destroyed, and then fell perpendicularly. Other writers supposed, that its motion was at first rectilineal, then a curve, and then vertical; and Tartalea imagined that the curvilineal portion of its path was a circle which had the two rectilineal portions for its tangents. The writings of this author, and of those who treated of the theory of projectiles, have already been noticed under our article GUNNERY.

Among the writers of this period, we must not omit the name of J. B. de Benedictis, or Benedetti, whose labours have, in general, been overlooked by mechanical authors. In his work, entitled *Diversarum Speculationum Math et Phys. liber*, which appeared at Turin in 1585, he ascribes the centrifugal force to the tendency of bodies to move in straight lines; and hence he concludes, that if left to themselves they would escape in the direction of the tangent. He demonstrates that the forces in the bent lever are proportional to the length of the perpendicular let fall from the fulcrum on the line of direction of the forces, and refutes the errors of Jordanus and Tartalea in the case of the convergency of the directions of the forces. Uninfluenced by any improper regard for Aristotle, he frequently refutes his solutions of many mechanical questions. He assigns better reasons than the Greek philosopher for the easy rotation of a circle upon an inclined plane, ascribing it to be the circumstance that its centre of gravity never ascends. The ideas of Benedetti, on the system of the world, seem to have been more correct than those of his age. He attached a high value to the system of Copernicus, and would, no doubt, have been one of its supporters, had it been his lot to write upon the subject of astronomy. Benedetti has shown that the path of a ray of light, penetrating our atmosphere, is curvilineal, and by means of the geometrical analysis of the ancients, he has given the solution of several difficult problems.

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* "Cease your work, ye maids, ye who laboured in the mill; sleep now, and let the birds sing to the ruddy morning, for Ceres has commanded the water nymphs to perform your task: these, obedient to her call, throw themselves on the wheel, force round the axle-tree, and by these means the heavy mill." Palladius also speaks of water-mills.

† Beckman's *History of Inventions*, vol. i p. 227.

‡ Ib. vol. i. p. 371.

The subject of mechanics now began to assume the form of a science; and from this period the progress of discovery became regular and rapid. Simon Steven, or Stevens, mathematician to the Prince of Orange, and engineer of the Dukes of Holland, published a work on Statics in 1586 which contains many new and important truths. Without calling in the aid of the lever, he appears to have been the first who demonstrated directly the laws of equilibrium on an inclined plane. Besides treating of simple machines, he considers the ratios of the loads supported by two powers which carry a weight at unequal distances, and also the effort made by a weight suspended by several cords against the powers which support it by their means. In resolving these and other mechanical questions, he makes use of the celebrated principle, which afterwards formed the basis of the mechanics of Varignon. He formed a triangle whose three sides were parallel to three directions; namely, to that of the weight and the powers which support it; and he shows that these three lines are respectively proportional to the weight and the powers. This principle is nothing else than the parallelogram of forces, and cannot fail to be regarded as one of the finest discoveries in mechanics. Stevens has been considered as the inventor of the chariot moved by the action of the wind upon sails, which is said to have outstripped, on the level roads of Holland, the best equipped vehicle. Stevens wrote likewise a work on Hydrostatics, and another entitled *Fortifications par ecluses*. His works were collected and printed in Dutch at Leyden in 1605. They were translated into Latin in 1608, and into French in 1634.

Lucas Valerius, professor of mathematics at Rome, took up the subject of the centre of gravity where it was left by Archimedes. The Syracusan philosopher had, with the exception of the parabolic conoid, entirely neglected the centre of gravity of solid bodies. Commandin had attempted, without success, to supply this defect; but it was reserved to Valerius to perform the task with such ample ability, as to have received from Galileo the appellation of the *Novus nostræ ætatis Archimedes*[*], —"the Archimedes of the present age." In his work, entitled *De Centro gravitatis solidorum*, which appeared at Rome in 1604, he has determined the centre of gravity in all conoids and spheroids, and all segments of those solids cut by planes parallel to the base.

Brilliant as were the discoveries of Galileo in the science of astronomy, his mechanical labours must always be regarded as a more striking proof of his transcendent genius. In the year 1592, he composed a small treatise on statics, founded on the principle that the same force is necessary to raise two different weights to heights which are reciprocally proportional to these weights; that is, that the same force is required to raise two pounds to the height of one foot, that is required to raise one pound to the height of two feet; and hence it followed, that in all machines in a state of equilibrium, the powers which are opposed to each other are reciprocally proportional to the spaces which they tend to describe in the same time. This important principle was not pursued by Galileo to its full extent. Descartes in his treatise, entitled *Explications des Machines et Engins*, applied it to the determination of the equilibrium of all machines, without, however, acknowledging the priority of Galileo. The great step which Galileo made in mechanics, was his discovery of the general laws of motion uniformly accelerated; and the agreement of this theory with the phenomena of nature, may be considered as laying the foundation of the theory of universal gravitation. After he was appointed a professor in the University of Pisa, he attacked the fundamental axiom of the Peripatetic Philosophy, that the velocities of falling bodies were proportional to their weights; and by letting fall heavy bodies from the top of the church, he demonstrated its fallacy by direct experiment. Crowds of spectators came to witness this exhibition; and the popularity which he thus acquired, excited so much hostility against him among the adherents of Aristotle, that Galileo was obliged to quit Pisa, and accept of a chair in the University of Padua. The same important fact was subsequently established by two pendulums of the same length, but of different weights, which Galileo found to perform the same number of vibrations in the same time. The law of the acceleration of heavy bodies was also determined by Galileo. It had been supposed by some, that the spaces described in equal times increased as the segments of a line divided in extreme and mean ratio; while it was more commonly maintained, that the increment of the velocity was proportional to the space previously described. Galileo showed, on the contrary, that the increment of the velocity was proportional to the times, that is, that after double the time, the velocity would be double. As the force of gravity may be considered as uniform in small distances, and as it acts unceasingly, the body is constantly receiving from it equal impulses in equal and successive instants of time; and, consequently, when it falls freely, these perpetually accumulating impulses must produce equal increments of velocity in equal times. Galileo begins by supposing this law of acceleration to exist; and after investigating its properties, he shows, by experience, that they are conformable to what actually happens in the fall of heavy bodies. He then demonstrates, that at the end of any given time, reckoning from the beginning of the fall, the body will have described half the space that it would have described in this time with the velocity which it had finally acquired; and that the spaces described are as the squares of the times, reckoned from the beginning of the fall.

Having found from experiment, that a body descending an inclined plane, or any curve whatever, had acquired the same velocity when it had descended through the same heights in the perpendicular fall, he concluded that there was the same ratio in the spaces described on inclined planes in unequal times, as in perpendicular falls, and after determining, by experiment, that in the descents of inclined planes, the space described was as the squares of the times, he inferred, that the same law existed when the descent was perpendicular.

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[*] Galileo *Discurs. Math.* p. 27

Galileo had the merit of being the first person who suggested the pendulum, and its application to the measurement of time. At an early period of his life, he had discovered the isochronism of pendulums, that is, that the same pendulum performs its great and small vibrations in the same time; and he had observed that two unequal pendulums put in motion performed in the same time numbers of vibrations, which were reciprocally as the square roots of their lengths. It was reserved, however, for Huygens to carry these ideas to perfection, and to enrich science and the arts with one of their most invaluable resources. The discoveries of Galileo on the subject of projectiles, and on the resistance of solid bodies, have already been stated in our articles GUNNERY, and CARPENTRY. These various discoveries of the Pisan philosopher have been fully explained by himself in his celebrated work, entitled, *Discursus et Demonstrationes Mathematicæ circa duas novas Scientias pertinentes ad Mechanicum et motum Localem*, which appeared in 1638, and was dedicated to the Count de Noailles. It is divided into four dialogues. The first treats of the resistance of solid bodies when they are broken. The second treats of the cause of the cohesion of solid bodies. The third contains his theory of local motion, including equable motion, and motions naturally accelerated. The fourth treats of violent motion, or the motions of projectiles; and, in an appendix, he demonstrates several propositions relative to the centre of gravity of solids.

The theory of local motion, as established by Galileo, did not meet with a ready reception among his contemporaries. Baliani, a Genoese nobleman, and a good natural philosopher, published at Genoa, in 1638, the same year in which Galileo's great work appeared, a book called, *De motu Naturali Fluidorum ac Solidorum*, in which he endeavoured to substitute a law of acceleration, in which the velocities were proportional to the spaces, and has given as his own many of the finest discoveries of Galileo. Riccati, who does not consider Baliani as a plagiarist, informs us, that after the year 1611, Baliani had been engaged at Savona in experiments analogous to those of Galileo; and that as both their works were published in the same year, they were entitled to equal praise. We do not mean to pronounce the harsh sentence of plagiarism against Baliani, but it is well known that the discourses of Galileo were circulated in MS. through various parts of Europe, and had been communicated to several Italian philosophers: Baliani, therefore, might have heard of them, and there is considerable internal evidence in his writings, particularly in the new edition of his work which appeared in 1646, that he hesitated between different laws of acceleration, and did not entertain those fixed opinions which are generally the result of original research.

When Toricelli was engaged in the study of mathematics at Rome, the work of Galileo on local motion accidentally fell into his hands. After studying it with care, he composed a treatise on the same subject, and sent it to Galileo, who was highly pleased with the talent displayed by his young friend. Toricelli went to visit Galileo, but their friendship was of short duration, as the latter died a few months after. Toricelli enlarged his little work, and published it, along with his other mathematical writings, in 1644. He seems to have been the first who established the principle, "that when two weights are so connected together, that being placed in any position, their common centres of gravity neither ascends nor descends, they are in equilibrium in all these situations." By this principle, he demonstrates the ratio of the weights which are in equilibrio upon an inclined plane, and he might have applied it with equal success to almost every other statical problem. Toricelli then examined the motions of falling bodies and projectiles, and, besides bringing forward a number of new views, he shews that the orbits of all projectiles discharged from the same point, and with the same force, are parabolas which touch one another.

The invention of the steam-engine, which began about this time to be used as the first power of machinery, may be regarded as the most important step that the moderns have made in practical mechanics. The Marquis of Worcester has undoubtedly the honour of having published the first rude sketch of a steam-engine in his *Century of Inventions*, which appeared in 1663; but the still higher merit, of having actually constructed and used them in a greatly improved state, belongs to Captain Savary. This ingenious individual took out a patent for his invention, and described several of the machines which he had erected, in a work called the *Miner's Friend*, which appeared in 1696, and in another work published in 1699. In 1697, Dr. Papin, professor at Marpurg, published an account of some experiments which he had made on the force of steam as a mechanical agent; and, as Dr. Robison remarks, "he acknowledges that Captain Savary had also, without any communication with him, invented the same thing." To pretend, therefore, as has been recently done, that Papin was the inventor of the steam-engine, is to set aside the claim of the Marquis of Worcester, and to give to Papin a priority over Savary which he himself does not claim, and which actually belongs to our ingenious countryman*. In the hands of Newcomen, Beighton, and Blakey, the steam-engine underwent great improvements, but it was destined to attain the character almost of a new invention, from the high state of perfection to which it was brought by James Watt, Esq. of Heathfield. Previous to his great improvements, it had been used only as a hydraulic machine for draining rivers, or raising water. In our article on the *Steam Engine*, we shall give a full account of the history of this valuable machine. In the mean time, we cannot refrain from expressing that satisfaction which we feel as Englishmen, that the steam-engine was not only invented, but has received all its improvements and found all its applications in our own country. Mr. Watt has lived to see his invention applied to the various arts and manufactures of Birmingham, Manchester, Sheffield, and Glasgow; to have observed it dragging loaded waggons with all the skill and activity of animal life; to have seen it applied to the arts of printing and coining;

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* It has been said, we know not upon what evidence, that one Brancas, an Italian, employed steam as the impelling power of a stamping-engine, and published an account of his invention in 1629.

and to have witnessed its final triumph in navigating the ocean.

Among the distinguished mechanicians of this period, it would be unjust to omit the name of Dr. Robert Hooke, a philosopher who has never been surpassed in variety and fertility of genius. Although he has not added any thing to the theory of mechanics, yet the number and the importance of his inventions have given him a scientific character, which it has been the fortune of few to attain.. He invented the spiral spring for regulating the vibrations of a watch-balance; he contrived the clockmaker's cutting engine, and also a scapement for the small vibrations of pendulums. He found that the Catenarian curve, when inverted, was the best form of an arch. He applied the screw to the division of astronomical instruments. He invented the spirit-level, and proposed the construction of a steam-engine upon Newcomen's principle. See our article HOOKE.

The celebrated Christopher Huygens was equally distinguished by the importance of his theoretical discoveries, and the ingenuity of his mechanical inventions. One of the greatest inventions of this distinguished individual, was the application of the pendulum for regulating the motion of clocks. The first idea of the pendulum occurred to him in 1656, and about the end of 1657, he presented to the States of Holland a clock constructed upon this new principle. Considering, however, that the oscillations of his pendulum might, from different causes, happen not to be of the same extent, and fearing that these small differences might accumulate to a sensible amount, he set himself to contrive some method of making them geometrically equal. In doing this, he demonstrated in general, that the velocity of a heavy body descending along any curve is the same at every instant in the direction of the tangent, as it would have been had it fallen freely from a height equal to the corresponding vertical abscissa; and by applying this principle to the reversed demicycloid, he discovered the *tautochronism* of this curve, that is, that a heavy body beginning to descend from any point of the cycloidal arc, will always arrive at the same time at the lowest point of the curve. If the pendulum, therefore, could be made to vibrate in a cycloidal arc, all its vibrations, however long or short, would be isochronous, or performed in equal times. The contrivance by which Huygens accomplished this object, by making a flexible pendulum describe a cycloid, from its vibrating between two similar cycloidal cheeks, has been described in our article HOROLOGY, and represented in Plate CCC, Fig 4. This ingenious contrivance, though it has turned out of no practical value, conducted its author to the celebrated theory of evolutes.

By these researches respecting the pendulum, Huygens was led to the subject of the centre of oscillation, one of the most important and difficult in mechanics. In 1646, Mersennus had proposed to philosophers to determine the centre of oscillation of a compound pendulum, or that point in which if a small insulated body were placed, it would oscillate in the same time as the system of bodies which composed the compound pendulum. Descartes, Roberval, and Huygens, though he was then very young, were particularly invited to solve the problem. Roberval and Descartes succeeded in solving some particular cases, but the methods which they used were far from being correct. Huygens, who was more successful, discovered the true principle, and was led to the beautiful theory which forms the fourth part of his *Horologium Oscillatorium*. The fundamental principle of this theory is, that if a pendulum with several weights attached to it descends by the force of gravity; and if these bodies are detached from one another at any instant, so as to ascend with the velocities which they have acquired, the centre of gravity of the system will rise exactly to the same height as that from which it had fallen. The solution which Huygens deduced from this principle, was at first attacked by the Abbé Catelan, as too little connected with the fundamental laws of mechanics; but the views of Huygens were supported by James Bernoulli and the Marquis de L'Hospital; and the principle of it has since been demonstrated in the most complete manner, and is known by the name of the *principle of the conservation of living forces*. The problem of the centre of percussion, which Mersennus also proposed, was imperfectly resolved by several geometers, but it was long after accomplished by James Bernoulli.

The theory of central forces, which was also given by Huygens, forms the fifth part of his *Horologium Oscillatorium*. By considering all curves as composed of an infinite number of small circular arcs of different radii, as Huygens had done in his theory of evolutes, the theory of central forces may be applied to the motion of a body in any curve. Huygens published his theorems without demonstrations. They were first demonstrated by Dr. Keill in his *Introduction to Natural Philosophy*. Those of Huygens were afterwards given in his posthumous works.

The true laws of collision or impact were about this time discovered separately by Wallis, Huygens, and Sir Christopher Wren. Descartes, misled by his metaphysical principles, had been induced to believe that there existed always the same quantity of motion in the universe; and hence he concluded, that the sum of the momenta after compact was equal to the sum of the momenta before it. This conclusion, which is true in the arcs when one of the bodies is at rest, or when one of them is moving before the other with a smaller velocity, is decidedly erroneous when the two bodies meet one another; for the sum of the motion after collision is then equal to the difference of the motion before it. The laws of collision, as delivered by the three geometers whom we have already named, were transmitted to the Royal Society of London in the year 1668, and were published in the 43d and 46th numbers of their *Transactions*. The researches of Wallis, whose solution of the problem is the most direct, were first presented to the society; Sir Christopher Wren's was next sent; and those of Huygens, whose method was the same as Wren's, arrived last, on account of his residing on the Continent. The fundamental principle of these different solutions is, that in the mutual collision of bodies the absolute quantity of motion of the centre of gravity is the same before as after compact. Wallis at first treated only the cases where the bodies were absolutely hard or soft; but he afterwards extended his theory to elastic bodies in his treatise *De Motu*, which appeared 1670.

In the year 1639, J. Marc Marci de Crownland, a Hungarian physician, published at Prague a work, entitled *De Proportione motus, seu regula sphymica*, in which he has treated of the collision of bodies. He divides bodies into soft, and hard, or those which preserve their figure after collision. He attends chiefly to the last kind, and has given precisely the same rules which are commonly given for elastic bodies. Montucla remarks, that he leaves it to his readers to judge how far the mathematicians, who established the laws of collision, may have been aided by the views and reasonings of Marci; but we think there can be no doubt that Wallis, Huygens, and Wren, were men of too high character to have omitted the name of Marci, if his works ever fell into their hands.

Alphonso Borelli, who had studied the subject of the communication of motion, entertained more correct notions on the subject than Descartes. In 1667, he published at Bologna his work *De Vi Percussionis*, in which he attempts to demonstrate, without much success, the nature, cause, properties, and effects of percussion. In 1670, he published another work, *De Motionibus, Naturalibus, a Gravitate pendentibus;* but the work upon which his fame principally rests, is his treatise *De Motu Animalium opus posthumum duabus partibus constans, quarum prima de motionibus conspicuis animalium nempe externarum partium et artuum flexionibus, et tandem de gressu, volatu, natatu et eorum annexis* Romæ 1681, in 4to. *Pars altera in qua de causis motus musculorum,* &c. Romæ 1682. In the first part of this work, which had much success, Borelli exhibits great sagacity in his examination of the mechanism of the human frame, and in the conjectures which he forms respecting the views of the Creator in arranging and proportioning the parts of this wonderful machine. See our life of BORELLI.

Beside his discovery of the laws of collision, Sir Christopher Wren was the author of several mechanical researches and inventions. He wrote on the general theory of motion; on the resistance of fluids to bodies which traverse them; on the construction of vessels; and on the motion of oars and sails. He invented several machines for grinding lenses, of a hyperbolic form, (see *Phil. Trans.* No. 59.); an instrument for drawing landscapes, or figures of any kind, (see *Phil. Trans* No. 60); and a number of other optical and astronomical instruments. As an architect Sir C. Wren was of the highest order. His churches of St. Paul's and Mary-le-Bow are striking monuments of his fine taste, as well as of his mechanical genius. See *Civil* ARCHITECTURE, where we have given a full account of his architectural labours.

One of the greatest steps in practical mechanics was made about this time by Olaus Roemer, a Danish philosopher, who had already distinguished himself by his great discovery of the successive propagation of light. In studying the subject of toothed wheels, he discovered that the curvature of their acting surfaces should be that of an epicycloid; and he seems to have communicated this discovery to the Academy of Sciences in 1675, in a memoir on toothed wheels. M. de la Hire published the same discovery in 1695, and in claiming the invention as his own, he states that he made it in 1674, and had communicated it to MM. Auzout, Mariotte, and Picard. It is, however, expressly stated by Leibnitz, in his letter to John Bernoulli, that Roemer communicated to him the discovery 20 years before De la Hire published it; and that when he was in Paris, Roemer was always considered by the philosophers of that day, and particularly by M. Huygens, as the inventor of this property of the epicycloid, while the name of De la Hire was never mentioned.

About this time, France produced several intelligent writers on mechanics, such as Mariotte, Varignon, and De la Hire, but they never reached any high degree of reputation, either by their works or by their inventions. M. Mariotte had the merit of being the first who introduced experimental philosophy into France. In his *Traité de Percussion*, he has proved by argument, and by well devised experiments, the true laws of the collision of bodies, which had been given almost without demonstration. His works, which contain many things that are excellent in practical mechanics, were collected in 2 vols. and published at the Hague in 1717, and afterwards in 1740.

M. Varignon, who was born at Caen in 1654, was one of the most accomplished and assiduous mechanicians of his age. He published no fewer than about 78 papers in the Memoirs of the Academy, principally on subjects in dynamics and mechanics. In his *Projet d'un nouvelle Mechanique*, which appeared in 1687, he deduces the whole doctrine of statics from the single principle, that if three powers are in equilibrium round any point, each of these powers is proportional to the sine of the angle which it forms with the directions of the two others. This principle, which, though it undoubtedly belongs to Stevinus, owed its full developement and application to the French mechanician, and has therefore received the name of the principle of Varignon. The *Nouvelle Mechanique*, to which the preceding work was only an introduction, appeared after his death in 2 vols. 4to. in 1725. It is remarkable for great diffusion, and also for great perspicuity in the details. The second volume contains the first parts of the famous principle of virtual velocities, in a letter from John Bernoulli to Varignon, in 1717. The virtual velocity of a body is the infinitely small space, which any body under the influence of a moving force tends to describe in an instant of time. Varignon applied the principle to the equilibrium of all sorts of machines. In a memoir, entitled *De la resistance des solides en general, pour tout ce qu'on peut fairè d'hypotheses touchant la force ou la tenacité des corps a rompre, et en particulier pour les hypotheses de Galilée et de Mariotte*, and published in the Memoirs of the Academy for 1702, he has given a greater degree of generality to the theory of the resistance of solids.

In the year 1695, M. De la Hire published his *Traité de Mecanique, ou l'on explique tout ce qui est necessaire dans la pratique des arts, et les proprietes des corps pesants lesquelles ont un plus grand usage dans la Physique*, 12mo. This work, which appeared also in the 9th volume of the Memoirs of the Academy, from 1666 to 1699, contains much useful information on practical mechanics, and the descriptions of several useful machines. It is, however, principally remarkable for the *Traité des Epicycloides*, which is added to the edition given in the Memoirs of the Academy.

The *Principia* of Sir Isaac Newton, which may be regarded as the application of mechanics to the phenomena of the celestial bodies, gave a degree of importance to the science which it never before possessed; but as the details of his discoveries are so intimately connected with astronomy, we must refer the reader to our account of them under that article.

The motion of bodies in resisting media, which Newton has treated at great length in the second book of the *Principia*, belongs more to mechanics than astronomy. Wallis embraced the most simple hypothesis of a resistance of the ratio of the velocities, and has published his researches in the *Phil. Trans.* for 1687. The same subject was successively discussed by Leibnitz in the Leipsic Acts; by Huygens in his *Traité de Pesanteur*, in 1690, and by Varignon in a series of able but prolix memoirs, which appeared among those of the Academy for 1707, 1708, 1709, and 1710. The same subject was ably resumed by James Bernoulli in the Leipsic Acts for 1693; by John Bernoulli in his *Nouvelle Théorie de la Manœuvre*; and by Hermann in one of the chapters of his *Phoronomia*.

About this time commenced that war of mechanical problems which distinguished the close of the 17th century. In 1687, Leibnitz, with the view of defying the Cartesians, who affected to despise the new analysis, proposed the first of these, which was to determine what he called the *isochronous curve*, or the curve along which a body must descend, in order to describe equal vertical spaces in equal times. Huygens, without the aid of the differential calculus, succeeded in obtaining a solution of it; but that of Leibnitz's did not appear till 1689. Some time after, James Bernoulli likewise succeeded; and it appeared that the curve required was a cubical parabola, in which the square of the absciss, by the parameter, is equal to the cube of the ordinate. Leibnitz next proposed to find the curve by which a body should move, in order that its distance from a given point might always be proportional to the time. This line, to which he gave the name of the *paracentric isochronous curve*, was found by James Bernoulli in 1694; and Leibnitz and John Bernoulli soon afterwards published their solution of the problem.

The celebrated problem of the catenary was now proposed by James Bernoulli, who demanded the form of an infinitely slender cord or chain, hanging freely by its two extremities. Galileo had maintained that it was a parabola. A German geometer, Joachim Trogelas, had demonstrated that it was neither the parabola nor the hyperbola; but it was left to the two Bernoullis, Leibnitz, and Huygens, to determine the nature and proportion of the curve. Their solutions having been published in the *Leipsic Acts* without the analysis, our countryman, David Gregory, afterwards printed a solution of the problem in the *Phil. Trans.* for 1697.

These problems were followed by that of the form of an elastic plate, of the curvature of a piece of linen filled with water; of the curvature of a sail or flexible surface filled by the wind; and that of the curve of quickest descent, all of which were solved by John Bernoulli, and the solutions given in his *Lectiones Calculi Integralis*. Leibnitz, who admired the problem of quickest descent, was anxious, in spite of his other occupations, to solve it, induced John Bernoulli to extend the period of solution to other six months. In consequence of this delay, Sir Isaac Newton sent a solution about the beginning of 1697. James Bernoulli gives a second, and the Marquis de L'Hospital a third, all shewing that the reversed cycloid enjoyed the property which was required. The two Bernoullis, who were now almost in a state of open hostility, harassed each other with other mechanical and mathematical problems, which we have not room to notice at present. Some interesting details will be found in our account of the lives of these two distinguished mathematicians.

In his researches on the compound pendulum of the centre of oscillation, Huygens was led to the principle of the conservation of active forces, which consists in this—that, in the mutual actions of bodies, whether it takes place in the collision of elastic bodies, or is communicated from one body to another by threads or inflexible rods, the sums of the masses multiplied by the squares of the absolute velocities remain always the same. Huygens employed that principle only as a simple theorem in mechanics; but John Bernoulli considered it as a general law of nature, and by its assistance he obtained solutions of many problems which could not be resolved by direct methods. His son Daniel applied the same principle to hydrodynamics, and afterwards rendered it more general, by applying it to the motions of bodies influenced by their mutual attractions, or drawn towards fixed centres by forces proportional to any function of the distance. See *Mem. Acad. Berlin*, 1748.

The celebrated dispute about the measure of the forces of bodies in motion began early in the 18th century, and continued for 40 years to agitate the philosophical world. The opinion of Descartes, which had become the one generally received, that the force of bodies actually in motion was proportional to their simple velocity, was attacked by Leibnitz in 1686 in a treatise entitled *Demonstratio brevis erroris memorabilis Cartesii et aliorum circa legem naturalem*, When a body falls from the height of four feet, says Leibnitz, it acquires at the end of the fall a velocity double that which it had acquired by falling one foot, and at the same time it acquires a force capable of raising it to the height from which it has fallen. With a double velocity, therefore, it has acquired the force of raising itself to a height quadruple of that to which it would have risen by means of the velocity acquired by rising through the height of one foot. By the same reasoning it appears that a triple velocity would raise it to a height nine times greater, and so on. But the forces being proportional to the heights to which the same weights are raised, Leibnitz concluded that a body moving with a double velocity is endowed with a quadruple force, and therefore that the forces are as the squares of the velocities. Huygens is said to have entertained the same views as Leibnitz.

This attack upon the Cartesian opinion was boldly repelled by the Abbé Catelan. He maintained that Leibnitz had erred in omitting all consideration of the time in which the body ascended; and while he admitted the premises of Leibnitz, that a body with a double velocity would rise to a quadruple height, he insisted, that as it rose to this quadruple height in double the time, the force could not be regarded as quadruple, but only as double, since the force produced only a quadruple effect in a double time. In 1694, John Bernoulli began a correspondence with Leibnitz upon this subject; and though he at first opposed the new doctrine to such a degree as to irritate his friend, yet he afterwards became one of its warmest supporters. In the year 1724, the Academy of Sciences proposed the *Communication of Motion* as the subject of one of its prizes. Our countryman, Maclaurin, who was one of the competitors, though then only 26 years of age, attacked the opinion of Leibnitz, while John Bernoulli endeavoured to support it with all the vigour of his talents. The memoir of Maclaurin was crowned by the academy. This dispute was carried on for a long time afterwards, on the one hand by John Bernoulli, Hermann, S'Gravesande, Muschenbroek, Poleni, Wolff, and Bulfinger, who supported the Leibnitzian doctrine, and on the other hand by Maclaurin, Stirling, Clarke, Desaguliers, and the other English philosophers who opposed it. Succeeding philosophers, who could view the subject without individual or national prejudices, considered this dispute principally as one of words, in which both parties were in the right. Our celebrated countryman, Mr. Smeaton,* however, was led by his experiments on the mechanical action of water to adopt the Leibnitzian doctrine. The same opinion has since been maintained by Dr. Wollaston,† and more recently by Mr. Peter Ewart‡ of Manchester, who, in a very able paper, has illustrated it at great length, and pointed out its application to some problems which he conceives cannot be solved by the ordinary doctrines.

In solving the problem of the centre of oscillation, John Bernoulli was led to consider the process in which motion is communicated from one body to another, and in some measure anticipated the famous principle in dynamics which has immortalized the name of D'Alembert. This principle, which forms the basis of his *Traité de Dynamique*, which appeared in 1743, may be announced in the following manner: "Let there be several unelastic bodies, whose velocities in given directions are A, B, C, D, &c. Let these bodies impinge against one another, or attract or repel one another in any way whatever. The motions A, B, C, D, &c. are respectively decomposed into two others, viz. a and α; b and β; c and κ; d and δ, &c. which are such, that if these bodies had only the motions a, b, c, d, &c. they would be able to preserve their motion without mutually affecting each other; and that if they had only the motion α, β, κ, δ, they would remain in equilibrio. The motions a, b, c, d, will be those which they will take in consequence of their mutual action." By means of this principle, D'Alembert solved a great variety of problems which had escaped the sagacity of preceding mathematicians, among which the most important was that of the precession of the equinoxes, and an exact theory of the motion of fluids. M. Fontaine has claimed in his memoirs the principle of D'Alembert, of which he certainly seems to have had an idea in 1739; but, without encroaching upon the merit of Fontaine, we may consider D'Alembert as having made the principle his own, by the beauty and the extent of its application.

Another dynamical principle of great importance was discovered about this time by Euler, Daniel Bernoulli, and the Chevalier D'Arcy, and received the name of the conservation of the momentum of rotatory motion. The form under which it presented itself to Euler and Daniel Bernoulli was as follows: In the motion of several bodies round a fixed centre, the sum of the products of the mass of each body, multiplied by the velocity of its revolution, and by its distance from the centre, is independent of the mutual action of the bodies themselves, and is always the same, provided that the bodies are not influenced by an external cause. Euler published the principle in 1746, in the first volume of his works, and Daniel Bernoulli in the first volume of the Memoirs of the Academy of Berlin for 1746; and they were both led to it while investigating the motion of several bodies in a curve of a given form, and which can only turn round a fixed centre. The Chevalier D'Arcy published the same principle in a memoir dated 1746, but which did not appear till 1752, in the volume of the memoirs of the Academy for 1747. He found that the sum of the products of the mass of each body, by the area which its radius vector describes round a fixed centre, is always proportional to the times; a principle which is identical with that of Euler and Bernoulli, and may be regarded as a generalization of Newton's fine theorem respecting the areas described by the radii vectores of the planetary orbits.

Another celebrated principle, namely, that of least action, may be thus expressed. In the motion of bodies which act upon one another, the sum of the products of the masses by the velocities, and by the spaces described, is a minimum. Maupertuis, the author of this principle, deduced from it the laws of the reflexion and refraction of light, in the *Memoirs of the Academy of Sciences*, for 1744; and in the *Memoirs of the Berlin Academy*, for 1746, he applied it to the collision of bodies. In the *Leipsick Acts* for 1751, this principle was bitterly attacked by Koenig, professor of mathematics at the Hague, who, not contented with endeavouring to point out its errors, maintained that Leibnitz had stated the same principle in a letter to Hermann, bearing the date of 1707. In reply to these accusations, Maupertuis insisted upon the production of the original of Leibnitz's letter; but Koenig declared that he had only a copy of this and some other letters of Leibnitz, which he had obtained from M. Henzy of Berne, who had collected several of the papers of Leibnitz. As this person had been beheaded some years before, in consequence of an attempt to change the government of Berne, it was supposed that his papers would have been preserved by the government, and in this expectation the King of Prussia, at the request of Maupertuis, applied to the magistrates of Berne to search for the letters of Leibnitz among the papers of Henzy. A similar search was made among the papers of Hermann, but nothing could be found to sanction the opinion that such a letter had ever existed. The Academy of Berlin having taken a part in behalf of their president, Koenig returned his diploma as an academician, appealed to the public against its judgment, and added to his pamphlet the four letters of Leibnitz. In the subsequent year he published another attack upon the Academy, and this was followed by various pieces on both sides of the question. Voltaire, who had taken offence at Maupertuis for introducing the Abbé Raynal into the Academy in opposition to his opinion, entered the lists on the side of Koenig, and directed against Maupertuis the coarsest raillery. Maupertuis, however, kept the field, and Voltaire was obliged to leave Berlin in 1752.

The applications which Maupertuis had made of the principle of least action, were too particular to entitle it to rank among those general laws in mechanics which we have already mentioned. Euler, however, considered it in a new and more rigorous manner, and in his *Traité des Isoperimetries*, printed at Lausanne in 1744, he has shewn, in the motion of insulated bodies, that in the trajectories described by means of central forces, the integral of the velocity multiplied by the element of the curve is always a maximum or a minimum. Lagrange extended this principle to the motion of bodies which act upon one another in any manner whatever, and hence he deduced the new general principle, that the sum of the products of the masses, by the integrals of the velocities, multiplied by the elements of the spaces described, is always a maximum or a minimum. This principle Lagrange considers, not as a metaphysical one, but as the simple result of the general laws of mechanics ; and in the *Memoirs of Turin*, he has employed it in the solution of several difficult problems in dynamics. "This principle," says Montucla, "combined with that of the conservation of living forces, and developed according to the rules of the calculus of variations, gives directly all the equations necessary for the solution of such problems, and hence arises a method equally simple and general, for treating questions which relate to the motion of bodies ;" but this method is only a corollary of that which forms the second part of the *Mecanique Analytique*, and which has at the same time the advantage of being deduced from the just principles of mechanics.

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* *Phil. Trans.* 1776, p. 450

† *Phil. Trans.* 1806

‡ *Manchester Memoirs*, vol. ii. 1813, p. 105

The *Traité de Mecanique* of Euler, published in 1736, is one of the most important works that has appeared on the subject of mechanics, and embraces the whole theory of the rectilineal and curvilineal motion of an insulated body subjected to the action of any accelarating forces whatever, either in a vacuum or in a resisting medium. By using the analytical method, and employing the principle of the *vis inertiæ*, and that of compound motion, he has solved a great number of difficult problems, and has perfected the method of analysis itself by new and delicate integrations to which his subject gave rise.

About the year 1755, Professor Segner of Gottingen enriched mechanics with an important and fertile discovery respecting rotatory motion. In a memoir entitled *Specimen Theoriæ Turbinum*, published at Halle in 1755, he shows, that if rotatory motions in every direction are impressed on a body of any form or magnitude, and if it is afterwards abandoned entirely to itself, it will always have three principal axes of rotation; or, what is the same thing, all the motions of rotation with which it is influenced may always be reduced to three, which are performed round three axes perpendicular to one another, passing through the centre of gravity of the body, and preserving always the same position in absolute spaces, while the centre of gravity is either at rest, or moves uniformly in a straight line.

The theory of rotation thus begun by Segner was pursued by Albert Euler, in his memoir *sur l'Arrimage des Navires*, which was crowned by the Academy of Sciences of Paris in 1761. The elder Euler treated the subject in a similar manner, in the memoirs of the Berlin Academy for 1759, and afterwards in his work entitled *Theoria Motus Corporum Rigidorum*, published in 1765. D'Alembert afterwards showed in the 1st volume of his *Opusculeſ*, which appeared in 1768, that the solution of this problem may be deduced from the formula given in his memoir, for determining the motion of a body of any figure acted upon by any forces, which was published in 1761, in the first volume of his *Opuscules*.

M. Coulomb, one of the most eminent natural philosophers of the last century, directed the attention of mechanicians to the force of torsion, or that which arises from the elasticity of twisted wires. He has shown, that for all metallic wires, when the angles of torsion are not very great, the force of torsion is sensibly proportional to the angle of torsion ; that in the case of cylinders made to oscillate in virtue of the force of torsion, the duration of the oscillations is as the square root of the weights of the oscillating cylinders, and that when the diameters or weights of the cylinder remain the same, the times of the same numbers of oscillations are as the square roots of the length of the wires. These results, which M. Coulomb deduced from theory, were also confirmed by experiment. The great discoveries made by Coulomb, both in magnetism and electricity, and the important results to which he arrived respecting the resistance of fluids, were obtained by the application of the theory of torsion.

The science of mechanics is also indebted to Coulomb for a series of beautiful results respecting the nature and effects of friction. By employing heavy weights and bodies of a large size, he has discovered very important facts, which escaped the notice of preceding authors. One of the most singular of these is the influence of time in modifying the phenomena of friction. In some instances, the friction attained its maximum after the rubbing surfaces had remained in contact only one minute, while in other cases five or six days were necessary to the production of this effect. In order to move a weight of 1650 pounds, a force of 64 was at first only necessary. After continuing three seconds in contact with the surface on which it rested, 100 pounds were necessary ; and, at the end of three days, it could scarcely be moved with a force of 622 pounds. On the other hand, M. Coulomb discovered that the friction could be diminished by an increase of velocity, a result which might have been anticipated from the preceding results.

One of the greatest works on mechanics which has appeared during the 17th century, was the *Mechanique Analytique* of Lagrange, which was published in 1788. He reduces all the problems to general formulæ, the developement of which gives all the equations which are necessary for the solution of each ; he has brought under one point of view the different mechanical principles which have been discovered for facilitating the solution of problems ; and in shewing their mutual connexion and dependence, he has enabled us to form a correct opinion of their justness and extent. Lagrange is of opinion, that the general principles which may yet be discovered in the science of equilibrium, will be only the principle of virtual velocities under a new form, and differing from it only in the manner of expression. He shows that this principle is not only very simple and general in itself, but has the advantage of being capable of translation into a general formula, which contains all the problems that can be proposed on the equilibrium of bodies. He explains this formula in all its extent ; and placing it in a point of view still more general than had been done before, he gives new applications of it for any system of forces whatever.

Having thus given a general view of the history of mechanics, we shall conclude this part of the article with a list of the most useful works and memoirs on the subject.

Aristotle *Questiones Mechanicæ.* Archimedes *Isoporrica seu de Equiponderantibus.* Cardan de *Ponderibus et Mensuris* Nemorarius *De Ponderositate.* Guido Ubaldi *Mechanicarum Libri sex*, and *In Archimedem de Equiponderantibus Paraphrases.* Benedetti *Diversarum Speculat. Math. et Phys. Liber.* Turin, 1585. Lucas Valerius *De Centro Gravitatis solidorum*, Rom. 1604.

Stevin *Oeuvres Mathematiques*, 1634. Galileo *Discursus et Demonstrationes Mathematicæ circa duas novas scientias pertinentes ad Mechanicam et motum Localem*, 1638. Cartesii *Mechanica*, in *Op. Posth.* Baliani *De Motu Naturali Fluidorum ac Solidorum*, Genoa, 1638. Baliani *De Motu Gravium*, Genev. 1646. Toricelli *De Motu Gravium Naturaliter accelerato*, 4to. Flor. 1644. Wallisii *Mechanica*, Lond. 1670. Huygens *De Horologio Oscillatorio*, 1673 Newton's *Principia*, *Phil. Nat.* De La Hire, *Traité de Mechanique*, Par. 1695. Leibnitii *Theoria Motus Abstracti*, Opera II. ii. 35. Hermanni *Phoronomia*, Amst. 1716. Camus *Traité des Forces Mouvantes*, Par. 1722. Id. *Cours de Mathematique*, liv. x. xi. Varignon *Nouvelle Mechanique*, Par. 1725. J. Bernoulli *Opera.* D. Bernouilli *in Nov. Comment. Petrop.* i. 126. Clairaut *in Mem. Acad.* Par. 1736, 105. 1742, 125. Euleri *Mechanica*, Petrop. 1736. Euleri *Theoria motus Corporum rigidorum*, Rost. 1765. Maclaurin's *Fluxions*, Edin. 1742. Chevalier D'Arcy, *Mem. Acad.* Par. 1747, p. 344. 1750, p. 107. D'Alembert *Traité de Dynamique*, Nor. 1743. Bossut *Traité Elementaire de Mechanique et de Dynamique.* Krafft, *Mechanica*, 1772. Emerson's *Mechanics*, 1794. Coulomb *Mem. Acad.* Par. 1781. Coulomb *Mem. des Sçavans Etrang.* tom. xix.. Ricati *Comment. Bonon.* II. ii. 305. Smeaton, *Phil Trans.* 1776. p. 450; 1782. p. 327. Atwood *on the Rectilineal and Rotatory Motion of Bodies.* Ferguson's *Lectures on Select Subjects in Mechanics, &c.* 2 vols. with Appendix, &c. Prony *Nouvelle Architecture Hydraulique*, Paris, 1790. Prony *Mecanique Philosophique*, Paris, 1799. Prony *Leçons de Mecanique Analytique*, Paris, 1810 and 1815. Carnot *Principes fondamentaux de l'Equilibre et de Mouvement.* Lagrange *Mecanique Analytique*, Paris 1788. Laplace *Mecanique Celeste*, 4 vols. Par. 1798. Francœur *Traite de Mecanique Elementaire*, Par. 1802. Eytelwein *Handbuch der Mecanik und der Hydraulik*, Berl. 1801. Wollaston, *Phil. Trans.* 1806. Milner, *Phil. Trans.* 1778, p. 344 Dr. Thomas Young's *Elements of Natural Philosophy*, 2 vols. Lond. 1807. Wood's *Mechanics*, Camb. 1803. Olinthus Gregory's *Treatise on Mechanics*, Lond. 1806. MM. Lanz and Bettancourt *Essai sur la Composition des Machines*, Paris, 1808. Poisson's *Traite de Mecanique*, 2 vols. 8vo. Paris, 1811. Playfair's *Outlines of Natural Philosophy*, Edin. 1814. Bridge's *Treatise on Mechanics*, Lond. 1814. Hachette's *Traite Elementaire des Machines*, Edit. 2d, Paris, 1819. Robison's *System of Mechanical Philosophy*, 4 vols. Edin. Borgni's *Traité complete de Mecanique appliqueè aux Arts*, Paris, 1818.

PART I. THEORETICAL MECHANICS.

THE theoretical branches of mechanics to which we propose at present to direct the attention of the reader, are, 1. Statics. 2. The mechanical powers; 3. The descent of bodies down inclined planes, the vibration of pendulums, &c. 4. The collision of bodies. 5. The rotation of bodies around fixed and moveable axes. 6. Torsion. 7. The maximum effect of machines. And, 8. The Principle of D'Alembert. The subjects of dynamics, the motion of projectiles, the equilibrium of arches, and the strength of materials, or the resistance of solid bodies, have been already treated in our articles DYNAMICS, GUNNERY, BRIDGE, and CARPENTRY.

CHAP. I.

ON STATICS.*

WHEN any number of forces that, acting separately, would produce motion in a body, are applied at the same time to that body, and so that no motion ensues in consequence of their application, they are said to balance one another, and the body is said to be in equilibrio.

Forces thus exerted are called pressures; and the science which treats of the laws of pressure and equilibrium in relation to solid bodies, is denominated *statics*, from a Greek word, signifying to weigh.

Pressures, viewed abstractly as the objects of statics, differ in only two respects—quantity and direction.

The quantity of a pressure is estimated by reference to some standard force of the same kind. A pressure is said to be equal to another, when, being applied in a contrary direction, it would balance it, or when each of the two, being separately applied in the same direction, would balance the same third force. Two such pressures, when their actions conspire, constitute a double pressure, three a triple pressure, and so on.

The direction of a pressure is that in which it would produce motion if unbalanced.

In the demonstration of statical theorems, the directions of pressures are represented by straight lines, and their quantities by lines or numbers.

When a particle of matter subjected to pressure is in equilibrio, it may be conceived as acted upon by two equal and opposite pressures; and when the force that balances a certain pressure, and is conceived as equal and opposite to it, is the effect of what may be considered as separate forces, it is denominated their resultant or equivalent.

The subordinate laws of statics may be derived, by reasoning strictly demonstrative, from a few principles, the result of universal and familiar experience, which, with one or two very obvious deductions, referable to the principle of the *sufficient reason*, we shall here state as physical axioms.

Ax. 1. The resultant of any two forces applied to the same point, in directions making an angle, must have a direction intermediate between those of the constituent forces.

Ax. 2. If two equal pressures be applied to the same point, in directions making an angle, the resultant will bisect that angle.

Ax. 3. If two forces be equimultiples of two others, that act in the same directions respectively, whatever multiple each of the first two is of its part, the same multiple shall the resultant of the first two forces be of the resultant of the other two.

Ax. 4. If two forces applied to one point be both augmented or both diminished in the same ratio, and the direction of their resultant continue unchanged, the resultant will be augmented when the forces are augmented, and diminished when they are diminished.

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* The Editor has been indebted for this Chapter on Statics to Dr. Jackson, Professor of Natural Philosophy in the University of St Andrew's.

Ax. 5. If a force be applied perpendicularly to an inflexible physical straight line, it cannot be balanced by a single force not directly opposed to it; and the two extremities, when prevented from moving, sustain a pressure which is equal to the whole force applied.

Ax. 6. If two equal and parallel forces, acting in the same direction, be applied to the extremities of an inflexible physical straight line, they will be balanced by a force equal to their sum applied to the middle point in a contrary direction.

Ax. 7. If any number of forces be in equilibrio, and any of them which would balance each other, considered separately, be removed, the remaining forces shall be in equilibrio.

Lemma I.

If the angles formed by the directions of two constituent forces and their resultant, be constant, while the constituent forces are increased or diminished in any ratio, the resultant shall be increased or diminished, respectively, in the same ratio.

Let AB and AC (Plate CCCLIX. Fig. 1.) represent two constituent forces, and AR their resultant; also let AB′ and AC′ represent two other constituent forces, and AR′ their resultant; then if AB be to AB′ as AC to AC′, AB shall also be to AB′ as AR to AR′.

For if AB and AB′ have a common measure, let it be A *b*, and let A *b*, A *c*, and A *r*, be like parts of AB, AC, and AR, respectively; then A *r* shall be the resultant of A *b* and A *c* by (Ax. 3.); and since AB′ and AC′ must be equi-multiples of A *b* and A *c*, whatever multiple AB′ is of A *b*, the same multiple shall the resultant of AB′ and AC′ be of A *r* (by the same); and since AR′ represents that resultant, AR′ : A *r* = AB′ : A *b*. But A *r* : AR = A *b* : AB. Therefore, *ex æq.* AR′ : AR = AB′ : AB.

Though AB and AB′, and consequently AC and AC′, have no common measure; still, if AR be to AR′ as AB to AB′, AR′ shall represent the resultant of AB′ and AC′. For, if not, let it be represented by AF, a line less than AR′; take AG greater than AF, but less than AR′, and commensurable with AR, and as AR to AB, or as AR′ to AB′, so let AG be to AD; also as AR′ to AC′, so let AG be to AE; then AD is less than AB′, and AE less than AC′, and AD and AE are commensurable with AB and AC, and in the same ratio: consequently, by Case 1. their resultant is AG, which is greater than AF, the resultant of AB′ and AC′. But it is also less (Ax. 4.) Q. A. E. In the same way it may be proved, that AF cannot exceed AR′.

Lemma II.

If the equivalent of two pressures, which are in a constant ratio to each other, and are represented by the adjoining sides of a rectangle, be always represented in direction by the diagonal passing through the point at which they meet, it shall be represented by the same in quantity also.

Let ABCD (Plate CCCLIX. Fig. 2.) be a rectangle, and AC the diagonal passing through A, the point to which the forces are applied; draw EAF perpendicular to AC, and let fall the perpendiculars BF, BH, DG, DE; then shall ABCD, AFBH, and AEDG, be similar rectangles; and if in each of these the resultant of the pressures represented in direction and quantity by the sides, be represented in direction by the diagonal, it shall be represented by the same in quantity also. For if the resultant of AH and AF be represented by AK, a line greater than AR, take AL and AM, so that AB shall be to AK as AD to AL, and AB to AK as AC to AM; also let AC be to AM as AM to AN: then the resultant of AE and AG will be represented by AL, the resultant of AB and AD by AM, and the resultant of AK and AL, that is of AH, AF, AE, and AG, by AN, (Lem. 1.) But AE and AF are equal and opposite; hence the forces AH and AG are equivalent to AN, that is, to a force exceeding their sum in the same direction, Q. A. E. In the same way, it may be proved that the resultant of the forces AH and AF cannot be proportionally represented by a line less than AB. It is therefore represented by AB; and the resultant of AB and AD is represented by AC, (Lem. 1.)

Prop. I. *Theorem.*

"Two pressures represented by the adjoining sides of a parallelogram, are equivalent to one represented by the diagonal which passes through the point at which these sides meet."

1. Let ABDC (Plate CCCLIX. Fig. 3.) be any square; and let the sides AB and CD be produced indefinitely towards B and D; draw the diagonal AD; in CD produced take DF equal to AD; join AF; take FH equal to AF; join AH, and so on: and complete the rectangles ACFE, ACHG, &c.

It is obvious that AD, AF, AH, &c. bisect the angles BAC, BAD, BAF, &c. respectively. Hence the resultant of AB and AC, which are always equal, must be represented in direction by AD (Ax. 2.); and therefore, by the same in quantity also, (Lem. 2.) The resultant of AE and AC being the same with that of BE and AD, which are always equal, will be represented in direction, and therefore in quantity, by AF; and thus may the proposition be proved with respect to any rectangle whose diagonal makes with one of the sides, any angle found by the continued bisection of a right angle.

2. Let (*a*) be any angle in the series above-mentioned; the proposition may be next proved in relation to any rectangle whose diagonal forms with one of the sides an angle that is in any multiple of (*a*.)

Let ABCD (Plate CCCLIX. Fig. 4.) be a rectangle whose diagonal AC makes with one of the sides an angle BAC, equal to any angle with respect to which the proposition may have been previously proved; draw AE, making the angle CAE equal to the angle (*a*), or any angle with respect to which the proposition has been proved, and meeting B *c* produced in E; and complete the rectangle ABEL: then shall the proposition be true with respect to the rectangle ABEL. For let EFH be drawn parallel to AC, and let fall the perpendiculars AH, FG, and EK; the latter meeting A *c* produced in K: and since HAG and FAB are right angles, $\angle HAF = \angle BAC$; and, by what is already proved in Case 1. AF is equivalent to AH and AG, that is, AF and AC are equivalent to AH, AG, and AC, or to AH and AK: but AH and AK are equivalent to AE, by Case 1. Therefore AE is the resultant of AC and AF; that is of AB, AD, and AF, or of AB and AL: for AF = CF = DL.

3. Let BAC (Plate CCCLIX, Fig. 5.) be an angle incommensurable with a right angle. The proposition is true in relation to BAE, the multiple of (a) next less than BAC; and in relation to BAG, the multiple of the same, which is the least that exceeds it; and the difference between these = (a,) may be taken less than any assigned angle. But the equivalent of AB and AD, that is of AE and FD, must fall below AE (Ax. 1.) and for the same reason the equivalent of the same AB and AD, or of AB, AH, and AK, equal and opposite to DH, that is of AG and AK, must fall above AG. The resultant of AB and AD must therefore, in respect of direction, be always intermediate between AE and AG; that is, it must be in the line AC: and as this is true in relation to any similar rectangle, or so long as the angle BAC remains the same, it must be represented by AC in quantity also, (Lem. 2.)

4. Let ABDC (Fig. 6 and 7.) be any parallelogram, whose angle BAC is less or greater than a right angle. From A, C, and D, draw the lines AE, CG, and DF, perpendicular to the sides CD and AB, produced when necessary; then, since the triangles ACG, BDF, are manifestly equal in all respects, and the side AG corresponds to the side BF, and since (by Case 3.) AC may be resolved into AE and AG, the latter of which conspires with AB when the angle BAC is acute, and is opposed to it when that angle is obtuse, the forces AB and AC are equivalent to AB, AG, and AE, or to AF and AE, that is, to AD. (Case 3.)

The proposition is therefore true universally as enunciated.

Note.—It is very common to speak of a force acting at A, as represented by a line BD, (Plate CCCLIX, Fig. 6.) in which the point A. is not situated. The meaning then is, that the force is represented in quantity by that line, and in direction by a line drawn from A parallel to it. In conformity to this language, Prop. I. may be enunciated thus:

"The resultant of any two forces acting at one point and represented by two sides of a triangle, is itself represented by the remaining side."

Cor. 1. Let the forces which are represented by the lines AB and AC, or AB and BD, (Plate CCCLIX. Fig. 6 and 7.) be denoted either exactly, or with sufficient approximation, by the numerical symbols a, b; and let the angle BAC be denoted by θ: Then, since $\mathrm{AD}^2=\mathrm{AB}^2+\mathrm{BD}^2 \pm 2\,\mathrm{AB}\cdot\mathrm{BF}=\mathrm{AB}^2+\mathrm{BD}^2+2\,\mathrm{AB}\cdot\mathrm{BD}\ \cos.\ \theta$, the analytical expression of the resultant will be

$$\sqrt{a^2+b^2+2ab\ \cos.\ \theta}.$$

Cor. 2. When it is necessary that a pressure R, represented by the given line AR, (Plate CCCLIX, Fig. 8.) should be applied at A, but by reason of some obstacle, we cannot employ for that purpose a single force = R, the end may be accomplished by two forces, P and Q, applied in such directions, AP and AQ, as may be convenient. In this case, when the directions of P and Q are given, their quantities may be determined; when their quantities are given, their directions may be determined; and when the quantity and the direction of the one are given, the quantity and the direction of the other may be found. Thus, if, when the directions AP, AQ, are given, that is, the angles which they make with AR given in position, we draw RD and RE parallel to AQ and AP respectively, AD will represent the force P, and AE the force Q. If AE be given, representing Q both in direction and quantity; join RE, and AD drawn equal and parallel to ER will represent Q. So, if the quantities are given, and the directions to be determined, it is manifestly reducible to the construction of a triangle whose three sides are given, and subject to a similar limitation. For trigonometrical calculation, when accuracy is required, we have given, in the 1st Case, one side of a triangle, AR, and the angles; in the 2d, two sides AR, AE, and the included angle; and in the 3d, the three sides.

Note.—The operation here described, is termed the resolution of forces; and is of the greatest utility in the investigation of statical principles, as well as in their practical application.

Cor. 3. When we resolve the force AR (Fig. 8.) into AD and AE, or AD and DR, and the latter is not at right angles to ADM, it may be further resolved into DB and BR, of which DB is in the direction of the line BM, and RB perpendicular to it. The only resolution that gives the whole effect of R reduced to the direction AM, is that which is effected by drawing the perpendicular RB. Then, as the force BR neither conspires with AB nor opposes it, the analysis is complete, and AB represents the whole effect of AR in the direction AM. Hence, if a force R, acting in any direction, be reduced to, or estimated in, another direction, making an angle θ with the former, the analytical expression of the force so reduced is R cos. θ.

Cor. 4. If two constituent forces be reduced to the same direction, the sum of the forces so reduced is equal to the resultant estimated in that direction. Let AB and BC be the two constituent forces, and AC their resultant. (Plate CCCLIX. Fig. 9.) Draw BD and CE perpendicular to AM, any line passing through A, and BF parallel to it, and meeting EC in F. The force AB, reduced to the direction AM, is represented by AD, and the force BC reduced to the same, is represented by BF or DE: and the sum is, AE = the resultant AC reduced to the same direction AM.

Cor. 5. If there be three forces, one of which is equal and opposite to the resultant of the other two; these three forces are in equilibrio; and the equilibrium will remain, in whatever common direction the three balanced forces are estimated.

Cor. 6. If three forces applied to one point be in equilibrio, they shall also be in equilibrio when reduced by orthographic projection to the same plane.

Cor. 7. Two forces applied to the same point, and their resultant, or any three such forces which are in equilibrio, and do not act in the same straight line, are proportional to the sides of any triangle whose three sides are parallel, or perpendicular, or any way similarly inclined to their respective directions.

Let ABDC (Plate CCCLIX. Fig. 10.) be a parallelogram whose two sides AB, AC, and diagonal AD, represent the two constituent forces P, Q, and their resultant R. These same forces may, consequently, be represented by the sides of the triangle, ABD, *viz.* AB, BD, and AD respectively: and, as any triangle whose sides are parallel to AB, BD, and AD, is similar to ABD, and the parallel sides are homologous, the same forces may be represented by the sides of this other triangle, which are parallel to their respective directions.

If it be thought necessary to prove the Corollary in so far as respects the other cases mentioned, it may be done as follows. Let ABC (Plate CCCLIX. Fig. 11.) be a triangle; from the point A, an acute angle, draw AA′ perpendicular to AB, and from the point C, another acute angle, CA′ and CB′ perpendicular to CA and CB respectively. The triangle A′B′C thus formed, will be similar to ABC. For ACA′ is equal to BCB′, each of them being a right angle, and if the common angle ACB′ be taken from each, there will remain B′CA′ = BCA. Moreover, ABCB′ is a quadrilateral figure, of which the angles A and C are two right angles. Therefore, ABC + AB′C = two right angles = AB′C + A′B′C, and A′B′C = ABC, consequently the triangles A′B′C and ABC are similar, and the perpendicular sides are homologous. Also, if the sides of any other triangle be perpendicular to those of the latter, they will be parallel to those of the former. It will be obvious that the forces will be represented in quantity by the sides which are perpendicular to their respective directions.

If we now conceive the side CB′ to be inclined to CB, at an angle greater or less than a right angle, and AB′ and A′C to be similarly inclined to AB and AC respectively, the sum of the angles BCB′, BAB′, will remain constant, whence the sum of B and AB′C will also be constant; and as B is constant, ABC′ and its supplement A′B′C will be constant. But BC′B is still equal to ACA′, and BCA = B′CA′ as before: therefore the truth of the whole corollary is manifest.

Cor. 8. Each of three forces, related as constituents and resultant, or each of three forces which are applied to one point, and are in equilibrio, may be represented in quantity by the sine of the angle contained by the directions of the other two: and any two of them are reciprocally as the perpendiculars drawn to their directions from the same point in the direction of the third force.

For, if AB (Fig. 10.) be represented by the sine of $\angle$BDA, or of $\angle$RAQ, or of its supplement D′AQ; then, since the sides of a triangle are as the sines of the opposite angles, AC or BD will be proportionally represented by the sine of RAP, or its supplement D′AP; and AD or AD′ by the sine of DBA, or of its supplement BAC. Moreover, since P : Q=sine QAR : sine PAR; P : Q=DF : DE, these lines DF and DE, drawn from any point D in the direction AR, perpendicular to AQ and AP, being the sines of QAR and PAR to rad. AD; and in the same manner may the other analogies referred to be deduced.

Cor. 9. Any number of forces acting at one point may be reduced to one resultant.

Let three forces acting at A (Plate CCCLIX. Fig. 12.) be represented by the lines AB, AC, and AD; from B and C draw lines parallel to AC and AB, meeting in E: then AE represents a force equivalent to AB and AC. From E and D draw lines parallel to AD and AE, meeting in F; then shall AF be the resultant of AE and AD, or of AB, AC, and AD; and by the same mode of proceeding, may any number of forces be compounded. The graphical process will be simplified, by omitting some parts of it which are unnecessary in practice. Thus, all that is essential to the composition here proposed is, to draw BE equal and parallel to AC, which determines the point E, and EF equal and parallel to AD, which determines the point F. A and F being joined, AF will represent the resultant sought. This has suggested the following elegant statical theorem. "If forces acting at a point A be represented by all the sides of a polygon but one, taken in order, as AB, BE, EF, FD, the resultant of the whole will be represented by the remaining side AD." The synthetic demonstration is obvious. By Prop. 1. the resultant of AB and BE is AE; that of AE and EF is AF; and that of AF and FD is AD. Hence, too, "if the forces be represented by *all* the sides of the polygon taken in order, they will be in equilibrio."

The forces considered in this corollary may be either all in one plane or not in one plane. In the latter case, the lines AB, AC, and AD, which represent them, are three adjacent linear sides of a parallelopiped; and the line AF, which represents their resultant, is manifestly the diagonal of the solid, which passes through the point at which the forces are applied.

If the forces to be compounded are many, the most convenient method of composition, and the best adapted to calculation, is that which proceeds by a previous resolution of each into its constituents, in the direction of rectangular axes of co-ordinates, given in position.

1. Let AP, AP′, AP″, &c. (Plate CCCLIX. Fig. 13.) represent any number of forces applied to the point A, and all acting in the same plane. Draw through A, and in that plane, any two straight lines A x and A y, at right angles to each other, and resolve the forces AP, AP′, AP″, &c. into AB, AB′, AB″, &c. whose sum let be AH, in the direction of the line A x; and AC, AC′, AC″, &c. whose sum let be AK in the direction of the line A y: complete the parallelogram AHRK, and join AR; then shall AR represent, in direction and quantity, the resultant of all the forces. Let the forces expressed numerically be denoted by the symbols P, P′, P″, &c. and the angles which their directions make with A x by α, α', α'', &c. respectively; and let AH be denoted by X, AK by Y, and AR by R; also let a denote the angle RA x. Then

$$X=P\cos.\alpha+P'\cos.\alpha'+P''\cos.\alpha''=\int P\cos.\alpha.$$

$$Y=P\sin.\alpha+P'\sin.\alpha'+P''\sin.\alpha''=\int P\sin.\alpha.$$

$$R=\sqrt{X^2+Y^2}.$$

$$\text{Cos. } a=\frac{X}{R}=\frac{X}{\sqrt{X^2+Y^2}}.$$

N. B. The process will be a little simplified, by taking one of the axes of the co-ordinates Ax or Ay in the direction of one of the forces.

2. Let the forces, one of which is represented by AP, (Plate CCCLIX. Fig. 14.) have their directions in different planes. Draw through A three straight lines Ax, Ay, Az, which may be considered as three adjacent linear sides of a rectangular parallelopiped; or such, that each of them is at right angles to the plane of the other two. From P let fall PB perpendicular to one of these planes, suppose that of Ax, Ay, and join AB. PB will of course be at right angles to AB, and AP is resolved into AB in the plane of x A y, and AE=BP perpendicular to it, or in the direction Az. Now draw BC perpendicular to AX, and BD perpendicular to A y; and AB may be considered as resolved into AC and AD in the directions A x, A y.

Thus AP is resolved into AC, AD, and AE, in the directions of the three axes A x, A y, and A z respectively. Let each of the forces be thus resolved, and let AF, AH, and AL, denote their sums in these respective directions. Then, by the former case, find AG, the resultant of AF and AH, in the plane x A y, and AR, the resultant of AG, and AL, in the plane GAZ; and AR will be the resultant of the whole.

With a view to calculation, let P, P′, P″, &c. and R denote as before the forces and their resultant; α, α', α'', &c. and a, the angles which their directions make with Ax; β, β', β'', &c. and b, those which they make with

A y; and $\gamma, \gamma', \gamma''$, &c. and c, those which they make with Az: also let X, Y, and Z denote the sums of the forces estimated in the directions Ax, Ay, and Az respectively. Then as $AR^2 = AG^2 + AL^2 = AF^2 + AH^2 + AL^2$, we shall have

$$R = \sqrt{X^2 + Y^2 + Z^2}.$$

Moreover, if RH and RF be joined, it will be obvious that AF=AR cos. RAF, and AH=AR cos. RAH; for the planes RGF, RGH, are at right angles to the plane x A y, and AF and AH in that plane are perpendicular to the common sections GF, GH, and therefore at right angles to the planes RGF, RGH, and to RF and RH respectively.

$$\text{Hence } R \cos. a = X, \text{ or } \cos. a = \frac{X}{R}.$$

$$R \cos. b = Y, \text{ or } \cos. b = \frac{Y}{R}.$$

$$R \cos. c = Z, \text{ or } \cos. c = \frac{Z}{R}.$$

Now $X = \int P \cos. \alpha$, $Y = \int P \cos \beta$, and $Z = \int P \cos. \gamma$, and are all given; therefore R, and the angles a, b, and c which determine its position, are given.

By the *sums* of the forces estimated in a particular direction, in such investigations as the preceding, we always understand such as are found by addition in the algebraic sense, the contrary directions being characterized by different signs, which again are determined by those of the cosines of the angles that the directions of the forces make with the *positive* co-ordinates, regarded as positive in the first and last quadrants of the circle, and negative in the second and third.

That the position of the resultant is determined by the angles a, b, and c, may be illustrated thus: Let x, y, z, and g (Plate CCCLIX. Fig. 15.) denote the points in which the axes A x, A y, and A z, and the line AG meet the surface of a sphere, whose centre is A, (Fig. 14;) the arches $x\,y$, $x\,z$, $y\,z$, and $z\,g$, are quadrants, and the angles at g right angles; and if x R, or x R′, the measure of a, and y R, or y R′, the measure of b, be given, they limit the point where the line of the resultant meets the spherical surface to one of two positions R, R′, both in the arch $z\,g\,z'$, and the one as much above g as the other is below it. The angle C, or its measure ZR, or ZR′, therefore, being also given, determines which of the two points R, R′ is to be chosen, and this, with the point A, determines the position of the line sought.

Cor. 10. When the forces thus resolved are in equilibrio, those which, after resolution, are in the direction of each of the rectangular axes, must be such as would balance each other, considered separately.

For, if any number of forces applied to one point be in equilibrio, each of them must be equal and opposite to the resultant of all the rest. Let P be one of the forces, and R′ the resultant of the remainder: these being equal and opposite, because they balance each other, will also be equal and opposite, when estimated in any common direction whatever, for they are reduced in the same ratio; and the resultant R′, reduced to that direction, is equivalent to its constituent forces P′, P″, P‴, &c. reduced to the same, as is manifest by Cor. 4. The same thing may be inferred in this way. Any force that may remain unbalanced in the direction of one of the axes A x, will, if compounded with any that may remain in the direction A y, produce a resultant in the plane x A y, and it is impossible that this should be balanced by any force that may remain in the direction A z, which is at right angles to it.

A just interpretation of the analytical expression of the resultant leads to the same conclusion; for, as $R = \sqrt{X^2 + Y^2 + Z^2}$ and X^2, Y^2, and Z^2 are always positive, whatever be the sign that distinguishes X, Y, or Z, the resultant cannot vanish unless X, Y, and Z vanish separately.

Lemma III.

"If an inflexible straight line, in an horizontal position, rest on two *fulcra* placed at its extremities, and a weight be suspended from a point in that line which divides it into two unequal segments, the pressure on the nearer *fulcrum* shall be greater than that on the more remote; and the more unequal the segments are, the greater shall be the part of the whole pressure which is supported by the nearer *fulcrum*."

Let AB (Plate CCCLIX. Fig. 16.) be the line, C the point of bisection, and D that at which the weight is applied: take DE equal to DB, and the pressure W may be conceived as resolved into two equal pressures, each equal to $\frac{1}{2}$ W, the one applied at B, and the other at E. (Ax. 6.) But a part of the pressure at E must be allotted to B, and the remainder to A. (Ax. 5.) B, therefore, supports more than the half of the whole, and A less than the half. Or thus: The pressure at D may be conceived to be somehow divided between B and C, as it would be were C supported by a fulcrum instead of the re-action of the fulcrum at A, propagated by the cohesion of the rod; and of that which is allotted to C one half may, by further resolution, be allotted to A, and the other half to B, so that the pressure at A is less than the half, being the half of a part, and consequently the pressure at B is more than the half of the whole. In like manner, if we suppose the weight W to be suspended from D′, a point nearer to B than D is, it may be conceived as divided according to some law between B and D; and now the pressure on A will be in the same ratio to the part which is allotted to D, that it formerly bore to the whole when applied at that point. It is therefore less, and consequently the pressure on B is greater than before.

Prop. II. *Theorem.*

"If an inflexible straight line in a horizontal position rest on two *fulcra* placed at its extremities, and a weight be suspended from any point in that line, the pressures on the *fulcra* shall be reciprocally as their distances from the point at which the weight is applied."

Let AB (Plate CCCLIX. Fig. 17.) be the straight line resting on the *fulcra* A and B; bisect AB in C, and AC in D; and let the weight be represented in quantity by AB. Then if it be applied at C, the pressures on A and B will be equal, (Ax. 6.) and in this case the proposition is obviously true. Let it be next applied at D. It will then be equivalent to AC applied at A, and AC at C; but AC applied at C is equivalent to $\frac{1}{2}$ AC at A, and $\frac{1}{2}$ AC at B. Therefore AB applied at D is equivalent to AC+$\frac{1}{2}$AC; that is, BD applied at A, and $\frac{1}{2}$ AC, that is, AD applied at B. In the same manner may the proposition be proved with respect to any segments found by the continual bisection of AB.

2. The proposition being true with respect to any segment, A *b*, and its supplementary segment B *b*, in the above mentioned series, shall be true with respect to any multiple of the first, and the supplement of that multiple. Let the point E (Fig. 17.) bisect the interval between any two successive points D, C, of the first mentioned subdivision, and let the force, represented by AB, be applied perpendicularly at E. This is equivalent to $\frac{1}{2}$ AB at D, and $\frac{1}{2}$ AB at C. But $\frac{1}{2}$ AB at D is equivalent to $\frac{1}{2}$ AD at B, and $\frac{1}{2}$ DB at A; and $\frac{1}{2}$ AB at C is equivalent to $\frac{1}{2}$ AC at B, and $\frac{1}{2}$ CB at A. Hence the whole pressure at A will be represented by $\frac{1}{2}$ DB $+\frac{1}{2}$ CB, *i. e.* EB, and that at B by $\frac{1}{2}$ AD$+\frac{1}{2}$ AC, *i. e.* AE. In the same manner may the demonstration be extended to the points which bisect DE and EC, if the line DC require farther subdivision to resolve it into segments, each equal to A *b*.

3. The proposition is true in relation to any segments of the line AB, which are not measured by A *b*. Let AD and DB (Plate CCCLIX. Fig. 18.) be such segments. The proposition has been proved in relation to AE, the greatest multiple of A *b* that is less than AD, and AF the least multiple of the same that exceeds it. That is, when a weight represented by AB is applied at E or at F, the pressure on B is represented by AE or AF respectively. But when the same weight so represented is applied at D, the pressure on B will be greater than AE, and less than AF; (by Lemma III.) and a line that is greater than any value of AE, and less than the corresponding value of AF, must be equal to AD. Hence the proposition is true as enunciated.

The two *fulcra* may be removed, and replaced by two forces equal to the pressures which they sustain, acting in a contrary direction; and the weight W, by any equal force, acting at the same point and in the same direction; and, from what has been demonstrated, it is manifest, that

"If three parallel forces be in equilibrio by the intervention of an inflexible straight line, to which their directions are perpendicular, any two of them will be inversely proportional to their distances from the point at which the third is applied."

This important statical theorem, usually denominated the principle of the lever, was first demonstrated, so far as we know, by the celebrated Archimedes; and it may not be improper that we subjoin to our own demonstration, recommended to us by analogy, one more nearly resembling that of the original author.

He requires, at the outset, the admission of two physical axioms: 1. That equal weights, suspended at equal distances from the fulcrum of a lever, are equiponderant, or balance each other when on opposite sides. 2. That if equal weights be suspended at unequal distances from the fulcrum, the more distant will preponderate. The first of these seems evident, and is the same, so far as it goes, with our 6th axiom. The second has been objected to, as assuming in part the thing to be proved; and in fact it seems to have been an inference, though an obvious one, from that axiom. It may have been made in the following way.

Let AE, (Plate CCCLIX. Fig. 19.) be a physical line supported by the *fulcrum* C, A and B two equal weights at equal distances, CA, CB, will balance each other. But the pressure B may be conceived as resolved into parallel forces, the one passing through the fulcrum C, and the other through any point D more remote than B for it does not appear that the distribution of this pressure should be different when D is supported by a *fulcrum*, and when it is in like manner simply prevented from descending, by the rotatory tendency of A, or by any other means. As the force which passes through C can have no effect in balancing A, it must of course be kept in equilibrio by that part of B which by resolution passes through D; and thus a less force than A or B, placed at D, would balance A, and a force equal to A, placed there, would preponderate.

Otherwise thus: Let A and B, (Plate CCCLIX. Fig. 20,) be two equal forces, acting in the parallel directions A *a*, B *b*; and let C be a force equal to their sum, applied to the point C, which bisects AB, and acting in the opposite direction C *c*. By Ax. 6, there will be an equilibrium, and the line ABM will have no unbalanced tendency to rotation about any point whatever, as *n* in CB, or *m* in AB produced, considered as an axis. Now, it cannot be doubted, that the force C acting alone, would produce a rotation about *n* or *m*. The equivalent of A and B must therefore be a force equal to C, acting in the direction C *c′*, opposite to C *c*. In other words, the equal forces A and B have the same effect in producing rotation as their sum, applied in the same direction, at the middle point between them; and this implies that A, which is on the same side of *n* with the middle point, will preponderate.

Now, let EF (Plate CCCLIX. Fig. 21.) be a lever, resting in a horizontal position upon the fulcrum C; and let M and N be any two weights applied to any two points E and F, which are on opposite sides of the fulcrum, and so situated, that M : N = CF : CE. In EF, produced towards both E and F, take EA equal to CF, and FB equal to CE; also from EC cut off ED, equal to AE or CF. Then AD is bisected in E, and DB in F; for DF = EC = FB. Let the sum of the weights M + N be uniformly applied to the whole line AB, so that an equal portion of that sum may rest on each equal part of the line; and there will be an equilibrium, (Ax. 6.) for every particle of the mass is balanced by an equal one, at the same distance from the fulcrum. Now, let the particle next to the point A, and that which is upon ED next to the point D, be both placed at E, and they will have the same tendency to turn the lever round as before;—the same thing may be affirmed of the equal particles next to these, and equidistant from E, and so on. Thus, the whole of the weights that rest on AD may be collected in E, and those which are upon DB may be collected at F, and the equilibrium will remain. Now, M : = CF : CE = 2 CF : 2 CE = AD : DB, or M + N : M = AB : AD and M + N : N = AB : DB. Therefore the weight now collected at E is M, and that collected at F is N; and, as an addition to either M or N, while the other remains constant, so as to destroy the ratio supposed, would also destroy this equilibrium, it is manifest that if M and N balance each other, M : N = CF : CE;

$$\left.\begin{array}{l}\text{also } M + N : M = FE : FC \\ \text{and } M + N : N = EF : EC\end{array}\right\} \text{Componendo.}$$

Whence, as (by Ax. 6.) we may substitute a force, M + N, at C, acting in a direction opposite to that of M and N, for the pressure on the fulcrum, the proposition is demonstrated.

Cor. 1. If three parallel forces be in equilibrio, by the intervention of an inflexible straight line, to which their directions are perpendicular, and if these forces be represented proportionally by three straight lines, the rectangles under the lines representing any two of them, and their respective distances from the point at which the third is applied, shall be equal; and conversely.

Cor. 2. If the arms of a lever make an angle with each other at the fulcrum, and two forces be applied perpendicularly to the arms, and be reciprocally as their distances from the fulcrum, these forces shall be in equilibrio.

Let ACB (Plate CCCLX. Fig. 1.) be a crooked lever having two arms AC, BC, which make an angle at C, where the fulcrum is supposed to be placed; and let M and N be two forces, represented by AM and BN, acting perpendicularly upon the arms AC, BC; and so related to each other, that $M : N = BC : AC$; or $M \cdot AC = N \cdot BC$; these forces shall be in equilibrio. Produce BC to D, making CD equal to CA, and let CD represent a physical line rigidly connected with the lever ACB. Suppose a force N′, represented by BN′, equal and opposite to BN, to be applied at B, and a force M′ to be applied at D, equal to M, and represented by DM′ perpendicular to DC. The lever will manifestly be in equilibrio: for N′ will balance N, and M′ will balance M, there being no reason that either should prevail. But since $M' = M$, and $N' = N$, and $M : N = BC : AC = BC : DC$, $M' : N' = BC : DC$; and M′ may be considered as in equilibrio with N′. Hence M and N must also be in equilibrio. (Ax. 7).

Cor. 3. If two forces, acting in the same plane, be applied to the arms of a lever, in any directions whatever, and be in equilibrio, they shall be reciprocally as the perpendiculars drawn from the fulcrum to their respective directions; and conversely.

Let ABC (Fig. 23 and 24.) be a lever, either straight or crooked; and let two forces M and N, represented by AM and BN, be applied to the extremities of the arms, and be in equilibrio: Then if AM and BN be perpendicular to AC and BC respectively, the corollary is already proved. But if they are not perpendicular, let CF and CG be drawn perpendicular to AM and BN, and M shall be to N as CG to CF. For let AM and BN be resolved into the forces AD and BE, in the directions of the arms, and DM and EN perpendicular to them: as AD and BE will be destroyed by direct opposition, or by the resistance of the fulcrum, which is supposed to be fixed, the equilibrium must be maintained, in so far as regards the tendency to rotation, by the forces DM and EN; and consequently $DM : EN = BC : AC$. (Prop. 2. and Cor. 2. of the same.) Now, as the triangles ADM and AFC are similar, as are also the triangles BEN, BGC, the two following series of quantities will be proportionals, in an inverse order:

$$AM : DM : EN : BN,$$
$$CG : BC : AC : CF;$$

Therefore, Ex. æq. in prop. perturb. $AM : BN = CG : CF$, or $M \cdot CF = N \cdot CG$.

The rectangles under the lines representing the forces, and the perpendicular distances of the directions in which they act from a fulcrum or axis, or the corresponding products, when the forces and distances are represented by numbers, may be adopted as measures of *momentum* or rotative energy, and are themselves generally denominated *momenta.*

Cor. 4. When two forces in the same plane are applied to the arms of a lever, and are in equilibrio, the pressure on the fulcrum is the same in quantity and direction as if both forces were immediately applied to that point, in directions parallel to the lines in which they are actually exerted.

This we have taken for granted, (Ax. 6.) when the lever is straight and the forces are parallel. It remains that we prove it of oblique forces applied to the straight lever, and of any forces applied to the crooked lever.

It is obvious that the forces AD and BE (Plate CCCLX. Fig. 2. and 3.) are propagated to the fulcrum, which, when the lever is straight, sustains also the sum of the perpendicular pressures DM and EN; and AD and DM, thus transmitted, will recompose a pressure equal and parallel to AM, while BE and EN produce one equal and parallel to BN. Now, let ABC (Fig. 4.) be a crooked lever, to which are applied, in directions perpendicular to the arms, the forces A and B: Produce BC to B′, making $B'C = BC$, and AC to A′, making $A'C = AC$, and let the forces A′ and B′, equal to A and B respectively, be applied perpendicularly to the arms A′C and B′C. Since A and B balance each other, A′ and B′ will also be in equilibrio, and the pressure on the fulcrum arising from A′ and B′ must be in the same line with that arising from A and B; (for the one will make the same angle with CA′ or CB′ that the other does with CA or CB respectively; and the pressure CF resulting from the four forces, A, B, A′, B′, will be double of that arising from the two A and B. But by the last case, the pressure arising from B and B′, is represented by CD, parallel to these forces, and equal to their sum; and that arising from A and A′ is represented by CE, parallel to them, and equal to their sum; and CF is the resultant of CD and CE. Therefore, when the forces A′ and B′, which are in equilibrio, considered separately, are removed, the pressure on the fulcrum will be reduced to ½CF, which is equivalent to ½CE, equal and parallel to A, and ½CD equal and parallel to B; whence the truth of the corollary is manifest.

Cor. 5. When three forces in the same plane, and not parallel, are in equilibrio by the intervention of any lever, their directions meet in one point, and the forces are such as would be in equilibrio, if applied to one point, while their directions preserved the same relative position.

Let ACB (Plate CCCLX. Fig. 5.) be a lever, whose fulcrum is C, and at the points A and B, let forces be applied, which are represented, in quantity and direction, by the lines AM and BN, meeting in some point as D. In the lines DA and DB, take DE and DG equal to AM and BN respectively, complete the parallelogram DEFG, and draw the diagonal DF; then shall DE and DG represent the forces AM and BN applied to the point D; and the resultant represented by DF shall pass through the point C. For, if it do not, let it meet AB in O, and draw the lines OP, CS perpendicular to DB and OQ, CT perpendicular to DA. Then $DE : DG = OP : OQ$, (Prop. 1. Cor. 8.) But $DE : DG\ (= AM : BN) = CS : CT$, (Prop. 2. Cor. 3.) which things are manifestly contradictory. The resultant, therefore, passes through C. Now let CH be drawn equal and parallel to AM or DE, and CK equal and parallel to BN or DG, and complete the parallelogram CHLK. The diagonal of this parallelogram $CL = DF$ will represent the pressure on the fulcrum, (Cor. 4;) and CH being parallel to DE, and the angle HCL equal to EDF, the two straight lines DC and CL must be in one and the same straight line, (GEOMETRY, Part I. Sect. I. Prop. 21 and 3.) But a force equal and opposite to that which is represented by CL, may be substituted for the resistance of the fulcrum, and will be in equilibrio with the forces A and B; whence the truth of the corollary is evident.

Cor. 6. When three forces in one plane, and not acting in parallel directions, are in equilibrio by the intervention of a lever, whose arms may be as hitherto represented by two straight lines, which are either in the same straight line, or make an angle with each other at the point where the third force is applied, they are proportional to the sides of any triangle whose three sides are parallel, or perpendicular, or in any way similarly inclined to their respective directions; each of them may be represented by the sine of the angle contained by the directions of the other two; and any two of them are reciprocally as the perpendiculars drawn to their directions from the same point in the direction of the third force. (Prop. 2, Cor. 5, and Prop. 1, Cor. 7 and 8.)

Now suppose the arms of the lever ACB, represented in fig. 26, to make an angle at C, the forces A and C are reciprocally as the perpendiculars drawn to their respective directions from B, which may be considered as a fulcrum, and they are in equilibrio. But A is applied to the extremity of a lever whose arm BCA is composed of two parts that make an angle with each other; whence it is obvious that the preceding corollaries relating to the simplest species of crooked lever, may be applied to any lever whatever.

Cor. 7. Two forces that are equal and opposite, will balance each other by the intervention of a solid body of any shape, though they be not applied to the same point. For if the body be regarded as a lever, having a fixed point or fulcrum, by Cor. 3, 4, and 6, there will be no unbalanced tendency to rotation, and no pressure on the fulcrum.

Cor. 8. A force, both in respect of its momentum and of the pressure excited at the fulcrum, may be conceived as applied at any point in the line of its direction, provided that point be connected, by an inflexible communication, with any point of the lever.

Cor. 9. If three forces, whether parallel or not, applied to a lever, be in equilibrio, their orthographic projections on a plane shall be in equilibrio, when applied to a lever represented by the orthographic projection of the former upon the same plane.

Cor. 10. Whatever forces be applied to a lever, and in whatever directions, if the sum of the momenta of the forces which tend to produce rotation in opposite directions be equal, there will be an equilibrium.

Let A, B, D, and E, (Plate CCCLX. Fig. 6.) be four forces applied perpendicularly to the arms of the lever AF, whose fulcrum is C, and let them act in the directions A a, B b, D d, and E e; A upon the one side, and the remainder on the other; then if $A\cdot AC = B\cdot BC + D\cdot DC + E\cdot EC$ there shall be an equilibrium. For in this case, A may be conceived as divided into three parts, A', A'', A''': Such that $B\cdot BC = A'\cdot AC$, $D\cdot DC = A''\cdot AC$ and $E\cdot EC = A'''\cdot AC$, and (by Prop. 2, Cor. 3.) these three parts A' A'' A''' will balance B D and E separately. Consequently their sum A will balance them jointly. Now let D and E be removed, and let B be such that $B.BC = A.AC$ and B will balance A. It appears, therefore, that the rotative tendency is the same in these two cases, or that the same force, acting at the same distance and in the same direction, will be balanced, when the sum of the momenta of the forces that oppose it is the same, whatever be the number of the forces. Hence we may substitute for A any number of forces under the like condition, just as for one force B may be substituted two or more forces B, D, or B, D, E, &c. under that limitation. This reasoning applies to any forces whatever acting in any directions. If any of them act in a direction opposite to that of the rest, which are applied to points on the same side of the fulcrum, it may be conceived as removed and replaced by a corresponding force on the other side; and if, in taking the sum of the momenta, it be estimated with a contrary sign, the condition of equilibrium will be, that the sum of the momenta on the one side of the fulcrum shall be equal to the sum on the other.

Otherwise thus:

Let A' and B', applied at H, and D', E', and F', applied at G (Plate CCCLX. Fig. 7.) balance A, B, D, E, and F respectively.

$$\text{Then } A'\cdot HC = A\cdot AC.$$
$$B'\cdot HC = B\cdot BC$$

and $(A'+B')\,HC = A\cdot AC + B\cdot BC$, and in the same manner, $(D'+E'+F')\,GC = D\cdot DC + E\cdot EC + F\cdot FC$.

But the second members of these last equations are equal, by hypothesis; therefore the first are equal: A' and B' will consequently balance D', E', and F'. (Prop. 2. Cor. 3.) and these being removed, the equilibrium will remain. (Ax. 7.)

Cor. 11. If any number of given parallel forces be applied to given points of a solid inflexible body, a point may be found through which their resultant will always pass, whatever be the position of a line to which their directions are parallel.

1. Let there be two forces, P and Q, applied at the points A and B (Plate CCCLX. Fig. 8.) and acting towards the same parts in any parallel directions, and let the point C be taken in the line AB, so that $Q : P = AC : BC$, or $Q+P : Q = AB : AC$. Through C draw DCE perpendicular to AP. It will also be perpendicular to BQ, and the triangles ACD, BCE will be similar. Therefore, since $Q : P = AC : BC$, we shall have $Q : P = CD : CE$, and P and Q will be in equilibrio, while the point C is subjected to a pressure in the same direction equal to their sum, (Cor. 3 and 4.) This pressure $R = P+Q$ is the resultant of the forces P and Q. The position of C depends solely on the quantities of the forces P and Q, or rather their ratio, and on the position of the points where they are applied.

2. Let the two forces, P and Q, be still in any parallel directions, but let them act towards opposite parts as in (Plate CCCLX.) Fig. 9. If they be equal, and their directions do not coincide, they cannot have any resultant; for it is evident, from the conditions of equilibrium formerly established, in the case of three parallel forces, that the one which is intermediate must act in a direction opposite to that of the other two, and be equal to their sum; which is here impossible. But if they be unequal, let Q be the greater, and in AB produced towards B, the point at which the greater is applied, take a point C, so that $Q : P = AC : BC$, or $Q-P : Q = AB : AC$. Through C draw CED perpendicular to AP. It will also be perpendicular to BQ, and the triangles ACD.

BCE will be similar. Therefore, since $Q : P = AC : BC$, we shall have $Q : P = CD : CE$, and P and Q will be in equilibrio, while the point C is subjected to a pressure equal to their difference, (Cor. 3 and 4.) This pressure, $R = Q - P$ is the resultant of the forces P and Q, and is always in the direction of the greater.

3. Let A, B and C (Plate CCCLX. Fig. 10.) be three points of a solid body, to which are applied three forces parallel to Ox, a line given in position, and let these points be connected by the inflexible straight lines AB, BC. For the greater simplicity of investigation, we shall also suppose, at present, that all the forces act towards the same parts. In the line AB find a point D, such that $A : B = BD : AD$; the resultant of A and $B = A + B = D$ shall pass through D, in a direction parallel to Ox. Join DC, and in the line DC find a point E, such that $D : C = EC : ED$, and R, the resultant of D and C, or of A, B, and C, shall pass through E in a direction parallel to the same line Ox. Now let the same forces, applied to the same points, act in lines parallel to Oy, another line given in position. By a similar investigation, the resultant of the whole R shall pass through E and in the same way may the proof be extended to any number of forces. If there be any parallel forces acting towards the opposite parts, a point E′ may, in like manner, be found, through which their resultant R′ shall always pass, under the limitations stated in the corollary; and finally, a point S, in the line EE′ produced, may be found, as in Case 2, through which will pass the resultant of the whole, when such resultant is possible; that is, the resultant of R and R′, when unequal, or if equal, directly opposed to each other. The point E or S, through which the resultant always passes, is denominated the *centre of parallel forces*.

Prop. III. *Theorem.*

"The momentum of the resultant of any number of forces acting in one plane, referred to a fixed point in that plane, is equal to the sum of the momenta of its constituent forces referred to the same; and that whether the directions of the forces be parallel or inclined to each other."

1. Let there be any number of parallel forces, A, B, D, (Plate CCCLX. Fig. 11.) acting in one plane, and from the point O, with reference to which the momenta are to be estimated, let there be drawn the straight line O E, perpendicular to their directions, and meeting them in A, B, and D. This line being considered as a lever, let C be that point at which a fulcrum being placed, the forces A, B, and D would balance each other. The pressure on C will be the resultant, or the sum of the forces, estimated with their proper signs; and $A.AC + B.BC$ will be equal to $D.DC$ under the same limitation; that is,

$$A\,(OC - AO) + B\,(OC - BO) = D\,(DO - OC),$$

or by transposition,

$$(A + B + D)\,OC = A.AO + B.BO + D.DO.$$

If the point O were situated between A and B, we should have $AC = OC + AO$, and the term $A.AO$ in the second number of the equation would become negative. In like manner, whatever be the position of O in the line OE, the distances on opposite sides of it are, in taking the sum of the momenta with reference to it, to be estimated with opposite signs.

2. Let ABDE (Plate CCCLX. Figs. 12 and 13.) be a parallelogram, AB and AE representing two constituent forces, and AD their resultant; and, from a point C in the plane of the figure, draw CG, CF, CH, perpendicular to the directions AD, AB, AE; join AC, and on AC as a diameter, and in the same plane, describe a circle, which will pass through the points F, G, H, because the angles subtended by AC at these points are all right angles. Join FH and GH. Then since $\angle GCH = \angle GAH = \angle ADB$, and $\angle CHG = \angle CAG$, the triangle CGH is similar to the triangle ADK. In like manner it may be shown that the triangle HCF is similar to the triangle ABK; whence

$$AD : DK = CH : CG \text{ or } AD.CG = DK.CH$$

and $AB : BK = CH : CF$ or $AB.CF = BK.CH$, and by adding equals to equals, when C is within the angle BAE on its vertical angle, and taking equals from equals when it is without, we shall have

$$AD.CG \pm AB.CF = BD.CH = AE.CH,$$
$$\text{or } AD.CG = AE.CH \mp AB.CF,$$

a conclusion which may be expressed as in the enunciation of the proposition, if the momenta of the forces tending to produce rotation in opposite directions be marked with opposite signs.

It is obvious that the forces AE and AB being each resolved into two constituent forces, and so on indefinitely, the proposition will still be true.

Cor. 1. This proposition, in so far as it relates to parallel forces, suggests a ready method of finding their centre, or the point through which the resultant always passes. We have only to suppose the forces, while applied at the same points, to act perpendicularly on the line, and divide the sum of the momenta, referred to any given point in the same, by the sum of the forces, the distances and forces being both estimated, as formerly, with characteristic signs: the quotient will be the distance of the centre of parallel forces from the point in reference to which the momenta are calculated, and its sign will indicate the direction in which it is to be taken.

Note.—It is usual among writers on statics, in treating of that part of the subject on which we are now entering, to designate by the term *momenta* the products of parallel forces into their distances from a point, line or plane, without any immediate reference to them as measures of rotative energy, or, in other words, without supposing, as above, that the given parallel directions are changed into others perpendicular to the lines which measure the above mentioned distances.

Cor. 2. If any number of parallel forces be applied to points which are all situated in the same plane, the sum of the momenta, with reference to any straight line in that plane, shall be equal to the momentum of their resultant with reference to the same.

1. Let the forces be all applied to points which are in the same straight line AE, (Plate CCCLX. Fig. 14.) as A, B, D; and let C be the centre of these parallel forces. From A, B, D, and C, draw lines Aa, Bb, Dd, Cc, perpendicular to Ox, the line with reference to which the momenta are to be calculated; and let AD, produced if necessary, meet Ox in S. Then, by the proposition

$$A.AS + B.BS + D.DS = (A + B + D)\,CS = C.CS, \text{ or}$$
$$A.Aa + B.Bb + D.Dd = (A + B + D)\,Cc = C.\,Cc,$$

all the terms being varied in the same ratio, viz. Rad: Sin. ESx.

If points of application lie on opposite sides of S, as in (Plate CCCLX.) Fig. 15, and the opposite directions be characterized, as usual, by opposite signs, the corresponding distances from Ox must also be distinguished in the same manner.

2. Let A, B, and D, (Fig. 16.) which are not in one straight line, be the points at which the forces are applied, and Ox any straight line in the plane of ABD. Find, as formerly, C, the centre of A and B, and E, the centre of A, B, and D, and draw Aa, Bb, Cc, Dd, Ee all perpendicular to Ox. Then, by the first case,

$$\mathrm{A.A}a+\mathrm{B.B}b=\mathrm{C.C}c, \text{ and } \mathrm{C.C}c+\mathrm{D.D}d=\mathrm{E.E}e,$$
$$\text{That is, } \mathrm{A.A}a+\mathrm{B.B}b+\mathrm{D.D}d=(\mathrm{A}+\mathrm{B}+\mathrm{D})\,\mathrm{E}e.$$

This suggests a convenient method of finding the centre of any number of given parallel forces applied to given points in one plane. Draw in that plane two rectangular axes of co-ordinates, Ox, Oy (Plate CCCLX. Fig. 17.) Let P, P′, P″, &c. be the forces, and R their resultant; that is, their sum or difference, according as they act in the same or in opposite directions. Let the perpendicular distances of P, P′, P″, &c. and R from Oy, or the ordinates parallel to Ox, be denoted by x, x', x'', &c. and $x_{,}$ and the co-ordinates of the same parallel to Oy, by y, y', y'', &c. and $y_{,}$. Then

$$\mathrm{R}x_{,}=\mathrm{P}x+\mathrm{P}'x'+\mathrm{P}''x'', \text{ \&c. or } x_{,}=\frac{\int \mathrm{P}\,x}{\mathrm{R}},$$

$$\text{and } \mathrm{R}y_{,}=\mathrm{P}y+\mathrm{P}'y'+\mathrm{P}''y'', \text{ \&c. or } y_{,}=\frac{\int \mathrm{P}\,y}{\mathrm{R}}.$$

In the lines O x and O y take OA and OB, such that their numerical measures are equal to $x_{,}$ and $y_{,}$ respectively, and draw, through A and B, AF parallel to O y, and BD parallel to O x; the point C, where these lines intersect, is obviously the centre of parallel forces sought.

Cor. 3. If any number of parallel forces be applied to points in any positions whatever, the momenta of these forces, with reference to any plane, shall be equal to the momentum of their resultant with reference to the same.

Let A B and D, (Plate CCCLX. Fig. 18.) represent the forces, and the points to which they are applied; and, without respect to their being necessarily in one plane, let MNPO represent a different plane, to which are drawn, from A, B and D, the perpendiculars A a, B b, and D d; and from C, the centre of the parallel forces A and B, and E the centre of the whole, perpendiculars C c and E e. The points a, c, b, are manifestly in one straight line, as are also the point c, e, d. (Playf. *Eucl.* Prop. 17. and Def. 2. B. 2. Suppl.) Hence (by Cor. 2.)

$$\mathrm{A.A}\,a+\mathrm{B.B}\,b=\mathrm{C.C}\,c, \text{ and } \mathrm{C.C}\,c+\mathrm{D.D}\,d=\mathrm{E.E}\,e,$$

$$\text{that is, } \mathrm{A.A}\,a+\mathrm{B.B}b+\mathrm{D.D}d=(\mathrm{A}+\mathrm{B}+\mathrm{D})\;\mathrm{E}\,e;$$

and in the same way may the proof be extended to any number of forces.

This suggests a convenient method of finding the centre of any given parallel forces applied to any given points. Assume three rectangular axes of co-ordinates, Ax, Ay, Az, (Fig. 14.) Let P, P′, P″, &c. be the forces, and R their resultant: Let the perpendicular distances of P, P′, P″, &c. and R from the plane z A y, be denoted by x, x', x'', &c. and $x_{,}$, the perpendicular distances of the same, from the plane z A x, by y, y', y'', &c. and $y_{,}$, and their perpendicular distances from the plane x A y by z, z', z'', &c. and $z_{,}$. Then

$$\mathrm{R}\,x_{,}=\mathrm{P}\,x+\mathrm{P}'x'+\mathrm{P}''\,x'', \text{ \&c. or } x_{,}=\frac{\int \mathrm{P}\,x}{\mathrm{R}},$$

$$\mathrm{R}\,y_{,}=\mathrm{P}\,y+\mathrm{P}'\,y'+\mathrm{P}''\,y'', \text{ \&c. or } y_{,}=\frac{\int \mathrm{P}\,y}{\mathrm{R}},$$

$$\text{and } \mathrm{R}\,z_{,}=\mathrm{P}\,z+\mathrm{P}'\,z'+\mathrm{P}''\,z'', \text{ \&c. or } z_{,}=\frac{\int \mathrm{P}\,z}{\mathrm{R}}.$$

The numbers $x_{,}$, $y_{,}$, and $z_{,}$, attention being paid to their signs, will give the position of three planes parallel to z A y, z A x, and x A y, respectively, in each of which the centre of parallel forces must lie. It will therefore be the point of their intersection which is given in position.

Cor. 4. It is obvious from the preceding investigations, that when the forces are given, and the points of their application, there is only one point which can be the centre of parallel forces.

Cor. 5. As in the demonstration of the second case of this proposition the resultant may be considered as applied at any point in the line of its direction, let x and y be the co-ordinates of any point in that direction, parallel to A x and A y respectively, and s and t the corresponding co-ordinates of any other point in the same; and let X and Y denote the constituent forces of the resultant R, the former parallel to A x, and the latter to A y; then shall

$$\mathrm{X}\;t-\mathrm{Y}\;s=\mathrm{X}\;y-\mathrm{Y}\;x,$$

each of these sums of momenta being equal to the momentum of the resultant.

Cor. 6. When the sum of the momenta of the constituent forces with relation to any point is $=0$, the resultant passes through that point—and conversely.

Prop. IV. *Problem.*

"To find the conditions of equilibrium in the case of parallel forces, applied to a solid body unconnected with any fixed point or fulcrum."

That such forces may be in equilibrio, it is plain that the resultants of those which have contrary signs must be equal and directly opposed to each other. These resultants being equal, if their momenta, with reference to any two intersecting planes, parallel to their directions, be equal, without regard to the signs, their perpendicular distances from these planes will be the same; or each of them will be in each of the same two planes parallel to these, and therefore in the line of their intersection. But the momentum of each resultant is the sum of the momenta of its constituent forces. Hence the conditions of equilibrium will be, "that the sum of the forces be $=0$, and that the sum of their momenta, with reference to two intersecting planes parallel to their directions, be $=0$; the sums of both the forces and the momenta being taken with regard to the signs."

Cor. If there be a fixed point or fulcrum, then, whatever be the forces applied, its resistance will supply the force requisite to fulfil the first condition, or will destroy the resultant of the given forces, provided it pass through that point. Now that resultant is situated in any plane, with reference to which the sum of the momenta is $=0$. The only condition, therefore, requisite in this case, is, "that the sum of the momenta be $=0$, with reference to two planes passing through the fixed point, parallel to the direction of the forces." In other words, a line joining the fixed point and the centre of parallel forces must be parallel to the direction of the forces.

PROP. V. *Problem.*

"To find the resultant, when possible, of any forces whatever, whose directions are situated in one plane."

Assume two rectangular axes of co-ordinates in that plane, Ox, Oy, (Plate CCCLX. Fig. 19.) Let P, P′, P″, &c. be the forces, and R their resultant, making an angle $= a$ with Ox. Let α, α', α'', &c. be the angles which P, P′, P″, &c. make with lines parallel to Ox. Resolve all the forces into their constituent forces parallel to Ox and Oy, the sums or resultants of which let be X and Y respectively; and let $x_{,}$ be the distance of Y from Oy, and $y_{,}$ the distance of X from Ox. Then we shall have the following equations:

$$X = \int P \cos. \alpha,\ y = \int P \sin. \alpha,$$

$$x_{,} = \frac{\int P\, x \sin. \alpha,}{Y} \quad y_{,} = \frac{\int P\, y \cos. \alpha}{X}$$

$$R = \sqrt{X^2 + Y^2}, \cos. a = \frac{X}{R},$$

Thus the magnitude of the resultant is given, a point through which it passes, viz. that whose co-ordinates are $x_{,}$ and $y_{,}$, and the angle which its direction makes with a line given in position. It is therefore in every respect determined, (due attention being paid to the signs of the quantities,) except in the case of the forces being reducible to two which are equal, with contrary signs, and not directly opposed to each other; and in this case, as formerly observed, no single resultant can be found.

PROP. VI. *Problem.*

"To find the conditions of equilibrium, when forces not all parallel to the same line, but all acting in directions coinciding with the same plane, are applied to a body unconnected with any fixed point or fulcrum."

There will evidently be an equilibrium if one of the forces be equal and directly opposed to the resultant of all the rest; otherwise not. Therefore, denoting one of the forces by P, whose direction we shall consider as positive, the co-ordinates of its point of application by x and y, the resultant of all the rest of the forces P′, P″, P‴, &c. by —R′, its constituent forces parallel to Ox and Oy by —X′ and —Y′, and the co-ordinates of their point of intersection, or of the centre of parallel forces, whose resultant is —R′ by $x_{,}$ and $y_{,}$, we may represent the conditions above-mentioned as follows:

Since P is equal and opposite to R′,

$$P \cos. \alpha = -X' = -P' \cos. \alpha' - P'' \cos. \alpha'', \&c.$$

$$\text{or } P \cos. \alpha + P' \cos. \alpha' + P'' \cos. \alpha'' = 0 \qquad (A)$$

$$\text{also } P \sin. \alpha = -Y' = -P' \sin. \alpha' - P'' \sin. \alpha'', \&c.$$

$$\text{or } P \sin. \alpha + P' \sin. \alpha' + P'' \sin. \alpha'', \&c. = 0 \qquad (B).$$

These equations, however, though resulting from the equality and direct opposition of the forces P and R′, would also result from their equality and parallelism, and therefore are not sufficient conversely to determine the coincidence of the directions. In order that the directions of R′ and P may coincide, we must have (by Prop. iii. cor. 5.)

$$X' y - Y' x = X' y_{,} - Y' x_{,}.$$

But $X' = R' \cos. a = -P \cos. a$, and $Y' = R' \sin. a = -P \sin. a$. Therefore,

$$-P\, y \cos. a + P\, x \sin. a = X' y_{,} - Y' x_{,}$$

$$= P' Y' \cos. a' + P'' y'' \cos. a'', \&c. - P' x' \sin. a' - P'' x'' \sin. a'', \&c.$$

$$\text{Or, } P\,(y \cos. a - x \sin. a) + P'(y' \cos. a' - x' \sin. a), \&c. = 0$$

$$\text{Or, } \int P\, y \cos. a - \int P\, x \sin. a = 0. \qquad (C).$$

COR. If there be a fixed point or fulcrum, whatever be the forces applied, their resultant will be balanced by the resistance of that point, provided it pass through it. Let X and Y be the constituent forces of the resultant, parallel to Ox and Oy respectively, and $x_{,}$ and $y_{,}$, the co-ordinates of the point of their intersection. Then, (by Prop. iii. Cor. 6.) $Xy_{,} - Yx_{,} = 0$, a condition which is obviously the same with that expressed by equation (C) above. It is here understood that the fixed point is taken for the intersection of Ox and Oy; or what is called the origin of the co-ordinates.

PROP. VII. *Problem.*

"To find the resultant, when possible, of any forces whatever, applied to any points of a solid body."

Assume any three rectangular axes of the co-ordinates Ox, Oy, Oz. Let P, P′, P″, &c. be the forces, and R their resultant, when possible, making with Ox, Oy, and Oz, the angles a, b, c, respectively. Let α, α', α'', &c. be the angles which the directions of P, P′, P″, &c. make with the axis Ox; β, β', β'', &c. those which they make with Oy; γ, γ', γ'', &c. those which they make with Oz. Resolve P, P′, P″, &c. into their constituent forces parallel to Ox, Oy, and Oz, the sums of which, or their resultants, let be X, Y, and Z, respectively. Then,

$$X = \int P \cos. \alpha;\ Y = \int P \cos. \beta;\ Z = \int P \cos. \gamma;$$

and consequently X, Y, and Z, are given.

Now, if all the forces can be reduced to one, that resultant may be resolved again into the same constituent forces; and, by following this process through the essentially different varieties, and applying Prop. i. Cor. 6. and Prop ii. Cor. 9. it will be evident that the projection of the resultant upon any of the three rectangular planes of the axes Ox, Oy, Oz. will be the resultant of the forces represented by the projections of its constituent forces upon the same. Let then the co-ordinates of X, parallel to Oy and Oz, be y_x z_x; the co-ordinates of Y parallel to Ox and Oz, x_y, z_y; and those of z parallel to Ox, and Oy, x_z, y_z; and let the three co-ordinates of any point of the resultant be x, y, and z. From the above-mentioned property of the projections upon the planes xOy, xOz, yOz, we shall have the three following equations:

$$(1.)\ Xy - Yx = Xy_x - Yx_y = \int Py \cos \alpha - \int Px \cos \beta = L$$

$$(2.)\ Zx - Xz = Zx_z - Xz_x = \int Px \cos. \gamma - \int Pz \cos. \alpha = M$$

$$(3.)\ Yz - Zy = Yz_y - Zy_z = \int Pz \cos. \beta - \int Py \cos \gamma = N$$

Here we may assign any given values to x; and since X, Y, and Z, are known, the first two equations will determine the corresponding co-ordinates y and z; and thus the position of the resultant, when possible, may be found. If these values do not render the third equation identical; that is, if $NX+MY+LZ$ be not $=0$, we shall conclude that the forces cannot be reduced to one resultant. When, by the substitution mentioned, that equation is satisfied, we have

$$R = \sqrt{X^2+Y^2+Z^2},$$

$$\cos. a = \frac{X}{R},\ \cos. b = \frac{Y}{R},\ \text{and } \cos. c = \frac{Z}{R},$$

Prop. VIII. *Problem.*

"To determine the conditions of equilibrium when any forces whatever are applied to any points of a solid body."

There will evidently be an equilibrium, if one of the forces be equal and directly opposed to the resultant of all the rest; otherwise not. Therefore denoting one of the forces by P, whose direction we shall consider as positive, the co-ordinates of its point of application by x, y, and z; the resultant of all the rest of the forces P', P'', P''', &c. by $-R'$; its constituent forces parallel to Ox, Oy, Oz, by $-X'$, $-Y'$, and $-Z'$; the co-ordinates of $-X'$, parallel to Oy and Oz; those of $-Y'$ parallel to Ox and Oz; and those of $-Z'$ parallel to Ox and Oy by $y_{x,}$, $z_{x,}$; $x_{y,}$, $z_{y,}$; and $x_{z,}$, $y_{z,}$, respectively, we may represent the conditions above-mentioned as follows:

Since P is equal and opposite to R',

$$(1.) \int P \cos. \alpha = 0. \quad (2.) \int P \cos. \beta = 0. \quad (3.) \int P \cos. \gamma = 0$$

investigated as equations A and B, Prop. 6. These equations, however, although resulting from the equality and direct opposition of the forces P and R′, would also result from their equality and parallelism, and therefore do not conversely determine the coindence of their directions. That the directions of R′ and P may coincide their projections upon the three planes, xOy, xOz, yOz, must also coincide. The analytical expression of the first of these conditions is that,

$$X'y - Y'x = X'y_{x,} - Y'x_{y,} \quad \text{But}$$

$X' = R' \cos. \alpha = -P \cos \alpha$; and $Y' = R' \cos. \beta = -P \cos. \beta$; therefore $-P y \cos. \alpha + P x \cos. \beta = X' y_{x,} - Y' x_{y,} = P' y' \cos. \alpha' + P'' y'' \cos. \alpha''$, &c. $- P' x' \cos. \beta' - P'' x'' \cos. \beta''$, &c. or

$$(4.) \int P y \cos. \alpha - \int P x \cos. \beta = 0$$

and in the same way, from the other conditions, we find

$$(5.) \int P x \cos. \gamma - \int P z \cos. \alpha = 0$$

$$(6.) \int P z \cos. \beta - \int P y \cos. \gamma = 0$$

Cor. If there be a fixed point or fulcrum, then, whatever be the forces applied, their resultant will be balanced by the resistance of that point, provided it pass through it; and this is the only condition of equilibrium in that case. Now the resultant will pass through it, provided its projections upon the planes of the axis pass through it, when it is taken for the origin of the co-ordinates; that is, provided (Prop. III. Cor. 6.)

$$(1.)\ X y_x - Y x_y = 0$$

$$(2.)\ Z x_z - X z_x = 0$$

$$(3.)\ Y z_y - Z y_z = 0$$

conditions which are identical with equations (4,) (5,) and (6,) above.

Of the Centre of Gravity.

The sensible gravitation of every particle of matter near to the surface of the earth is directed either to the centre of the terrestrial spheroid, or to a point very near to it. Hence, in considering the conditions of equilibrium, when gravity is one of the forces employed, and when none of the linear dimensions of the bodies concerned bears any sensible *ratio* to the radius of the earth, as is the case with respect to all our machinery, the gravitations of all the particles may be considered as parallel. The variations in the intensity of gravity, too, depending on such small differences of position as occur in mechanical combinations, are so very trifling, that they may be safely disregarded.

It appears, then, from what has been previously established in the general doctrine of parallel forces, that there must be in every body possessing weight a point, through which the resultant of the gravitations of its individual particles will pass, whatever be the position of any given points in it with respect to the constant vertical direction of this force. That point, or centre of parallel forces, is in this case denominated the centre of gravity. Its properties, when its position is known, introduce a very great simplification into most of our mechanical disquisitions; enabling us to state the conditions of equilibrium in relation to whole masses of matter, with the same ease and simplicity as we could formerly express those connected with similar combinations of as many single particles.

From what has been proved in Prop. II. and its corollaries, the statical properties of the centre of gravity will be manifest without much additional demonstration,—*ex. gr.*

If this point of a body be supported by a force equal to the body's weight, it will remain in equilibrio in every possible position.

If the centre of gravity be either vertically above, or vertically below the point of support, the body will be in equilibrio. But it will not now, as before, be indifferent to any position. When the centre is vertically above a point of support, the smallest inclination will altogether destroy the equilibrium, which explains the difficulty of balancing a body on a point or edge. When it is vertically below a point of suspension, if the equilibrium should be disturbed, it will, after some oscillations, be restored. The latter has been called a *stable*, the former a *tottering*, equilibrium.

If a body rest upon a horizontal plane, and the vertical line passing through the centre of gravity fall within the base, the body will stand; if without the base, it will fall: and when that line falls within the base, the farther the point in which it meets it is from the perimeter on any side, the firmer will be the stability of the body in its position: for the weight may always be conceived as acting wholly at the centre of gravity; and it is obvious, that the more distant any point in the perimeter of the base is from the vertical of the centre, the longer is the virtual lever by which the weight acts, and the greater its momentum to resist that of a given force similarly applied, and tending to produce a rotation about an axis passing through that point.

A body, whose centre of gravity is high, is more easily overset than one having the same base, and whose centre is lower. When we say that it is more easily overset, the meaning is, that it is overset by a smaller inclination, and is, therefore, from accident, overset more frequently. Thus a carriage loaded with wood hay, straw or the like, will be overset upon a declivity along which one loaded with the same weight of iron, lead, or stone, might be drawn transversely with safety; and a carriage of any kind, loaded at the top, is more apt to meet with such an accident than one that is not so. Hence, too, we may see the error of people starting up, as they are apt to do, from sudden alarm, when a carriage is nearly overturned.

We shall conclude this treatise with some propositions relating to the determination of the centre of gravity in various bodies: and, in this investigation, when we speak of a line or of a surface, we mean a physical line or physical surface, of uniform density, and having as little of the dimensions which are excluded from the geometrical conception of a line and surface, as the limits to the actual subdivision of matter will admit of.

1. *Right line.*—The centre of gravity of a right line, or single row of particles, connected by the force of cohesion, is evidently the point of bisection.

2. *Perimeter of a Polygon.*—The centre of gravity of each side being its middle point, that of the whole may be found by the method of momenta, (Prop. III. Cor. 2.) The quantity of matter in each side is, in this process of calculation, to be estimated by its length, or by the length and density jointly, if the latter be uniform throughout the whole of each side.

3. *Surface of a Triangle.*—Draw a straight line from any of the angles bisecting the opposite side, and let it be divided, so that the segment toward the base may be one-third part of the whole: the point in which it is so divided is the centre of gravity.

Let ABC (Plate CCCLX. Fig. 19.) be a triangle, and from A, one of the angular points, draw AD, bisecting the opposite side BC. Draw also any line, as FK, parallel to the base, meeting the sides of the triangle in F and K, and the line AD in H. Then, since (4. 6 Elem.) $BD : FH = AD : AH = DC : HK$, by alternation $BD : DC = FH : HK$. But $BD = DC$: therefore $FH = HK$, and the centre of FK is in H. Now the whole triangular physical plane may be conceived as made up of physical lines, as FK, parallel to the base, and bisected by AD. The centre of the whole is therefore in AD. Also, if CE be drawn bisecting the opposite side AB, the centre of the whole must be in CE. It is therefore in G, the point of intersection. Now, let ED be joined, and since $BD : DC = BE : EA$, ED is parallel to AC (Geometry, Prop. XVI.) and BDE, BCA are similar triangles; consequently $DG : GA = ED : AC = BD : BC = 1 : 2$, or by composition $DG : DA = 1 : 3$.

4. *Surface of a Parallelogram.*—The centre of gravity of a parallelogram is the point in which the diagonals intersect one another.

For, by the method of demonstration adopted with respect to the triangle, it is manifest that the centre of the whole must be in each of the diagonals. The same thing may be otherwise demonstrated by finding the centres of the triangles separately, or by drawing straight lines bisecting the opposite sides.

5. *Surface of any Polygon.*—Draw diagonals from one of the angular points, dividing the surface into triangles; find the centres of the triangles by case 3d, and the centre of the whole by the method of momenta, representing the quantity of matter in each of the triangles by its area.

For regular polygons, a shorter method will readily occur. If the number of sides be even, draw two diagonals joining opposite angles; if it be odd, draw from two of the angular points perpendiculars to the opposite sides. In either case, the point of intersection of the lines so drawn will be the centre.

6. *Prisms and Cylinders.*—In solids of these denominations, the centre of gravity bisects the straight line, joining the centres of gravity of their opposite ends. For a line so situated will pass through the centres of the laminæ, parallel to the ends into which the solids may be conceived as divided.

7. *Pyramids and Cones.*—Join the vertex and the centre of gravity of the base, and divide the intercepted line so that the segment towards the base may be one-fourth part of the whole: the point in which it is so divided is the centre.

1. Let VABC (Plate CCCLX. Fig. 20.) be a triangular pyramid, whose base is ABC, and vertex V; and let *a b c* be a section of the pyramid by a plane parallel to the base. Bisect two sides of the base AC and AB in in the points D and E, and let BD and CE be the intersections of the planes VBD, VCE with the plane of the base; and *b d c e* their intersections with the plane *a b c*, parallel to the base. Also, let VD and VE be their intersections with the planes VAC, VAB, and let these lines meet *a c* and *a b* in the points *d* and *e*. It is plain that G, the point in which BD and CE intersect each other, is the centre of gravity of the base; and since *a c* is parallel to AC, (Playf. *Eucl.* Prop. 14, B. 2. Suppl.) $AD : ad = VD : vd = DC : dc$, and by alternation $AD : DC = ad : dc$. But $AD = DC$; therefore $ad = dc$.

In the same manner it is proved, that *a b* is bisected in *e*; and thus the point *g*, in which *b d* and *c e* intersect each other, or in which VG cuts the plane of the triangle *a b c*, is the centre of gravity of that triangle. Now, the pyramid may be considered as composed of a number of such triangular laminæ parallel and similar to the base; and as the centre of each is in the line VG, the centre of the whole must be in that line. Again, let EF be taken equal to one-third part of EN, and join CF and FG: F will be the centre of gravity of the triangle VAB; and it may be demonstrated, as before, that the centre of the whole solid will be in CF. It must therefore be in H, the intersection of the two lines VG and CF, which are in one plane VEC. Moreover, since $EG : GC = 1 : 2 = EF : FV$, FG is parallel to VC; and $GH : HV = FG : VC = EG : EC = 1 : 3$. Therefore, by comp. $GH : GV = 1 : 4$.

2. Let there be a quadrangular pyramid, whose vertex is V, (Plate CCCLX. Fig 21.) and whose base is divided into two triangles, A and B, the centres of gravity of which are represented by G and F respectively. Join GF, and let GH be to HF as B to A: H will be the centre of gravity of the base. Let *g h f* be the intersection of the plane VGF, with a plane parallel to the base, and whose altitude above it is one-fourth part of the altitude of the pyramid. The centres of gravity of the two triangular pyramids whose bases are A and B, will be *g* and *f*, (by the preceding case, and Playf. *Eucl.* prop. 16. B. 2. Suppl.) and $hf : gh = HF : GH = A : B$; that is, since the pyramids have the same altitude as the py-

ramid whose base is A, to the pyramid whose base is B, and h will be the centre of gravity of the whole quadrangular pyramid. In the same way may the demonstration be extended to all other pyramids, and to cones considered as pyramids, the number of whose sides is indefinitely great.

Every physical solid bounded by plane surfaces may be divided into pyramids, and its centre of gravity may be found by the process now described, and the method of momenta, these being taken with reference to the planes of three rectangular axes. (Prop. III. Cor. 3.)

The investigation of a general rule to find the centre of gravity of curve lines or curve surfaces, and of solids bounded by them in whole or in part, requires an application of the higher geometry. The rule may be thus demonstrated.

Let s be the sum of the momenta, estimated with reference to any straight line or plane surface, up to a certain distance x; s' the sum up to any greater distance x', also let m and m' denote the quantities of matter between the given line or surface, and others parallel to them at the distances x and x' respectively. The increment of the sum of the momenta being the sum of the products of every particle in the mass $m'-m$ into its distance, will always be greater than the product of $m'-m$ by the least distance, but less than its product by the greatest: that is,

$$s'-s > (m'-m)\,x, \text{ but } < (m'-m)\,x'$$

$$\text{or } \frac{s'-s}{m'-m} > x, \text{ but } < x'$$

But if the contemporary increments be continually diminished, x' approaches to x as a limit: therefore x is also the limit of $\frac{s'-s}{m'-m}$ which is always intermediate between x' and x; that is, $\frac{\dot{s}}{\dot{m}} = x$, or $\dot{s} = x\,\dot{m}$, and $s = \int x\,\dot{m}$, and consequently the distance of the centre from the given line or surface is $= \frac{\int x\,\dot{m}}{\int \dot{m}}$. If its distance be found in this way from the planes of three rectangular axes, its place will be determined. If the particles of matter are all in one physical plane, we need only two axes of momenta; and if they be symmetrically arranged with respect to any straight line, so that the parts on each side are perfectly equal and similar, we need only one.

The general formula may be conveniently accommodated to cases of the latter description, as follows.

Let MAN (Plate CCCLX. Fig. 22.) represent a curve line whose axis of abscissæ is AC, and whose ordinates DE are all bisected by that line. Let $\mathrm{AB}=x$, the semiordinate $\mathrm{BD}=y$, and the arch $\mathrm{AD}=z$. The centre of gravity of the equal particles at the extremities of any ordinate, as DE, will be in the point which bisects that line, or the point in which it meets the axis of the abscissæ. Therefore, the centre of the whole curve DAE, or MAN, will be found in that axis. Let D be its distance from A. Then $\dot{m}=2\dot{z}$, and

$$\mathrm{D}=\frac{\int 2x\dot{z}}{2z}=\frac{\int x\dot{z}}{z}$$

If the figure represent a plane surface, $\dot{m}=2y\dot{x}$, and

$$\mathrm{D}=\frac{\int 2yx\dot{x}}{\int 2y\dot{x}}=\frac{\int yx\dot{x}}{\int y\dot{x}}$$

If it represent a surface of revolution, $\dot{m}=2\pi y\dot{z}$, and

$$\mathrm{D}=\frac{\int 2\pi yx\dot{z}}{\int 2\pi y\dot{z}}=\frac{\int yx\dot{z}}{\int y\dot{z}}$$

If it represent a solid of revolution, $\dot{m}=\pi y^2\dot{x}$, and

$$\mathrm{D}=\frac{\int \pi y^2 x\dot{x}}{\int \pi y^2\dot{x}}=\frac{\int y^2 x\dot{x}}{\int y^2\dot{x}}$$

EXAMPLES.

1. Let the figure represent a circular arch, whose centre is C, and whose radius is r: then $\dot{z}:\dot{y}=r:r-x$, $r\dot{z}-x\dot{z}=r\dot{y}$, or $x\dot{z}=r(\dot{z}-\dot{y})$ and $\int x\dot{z}=rz-ry$, which divided by z gives $\mathrm{D}=r-\frac{ry}{z}$; or the distance from the centre $=\frac{ry}{z}=\frac{r\times 2y}{2z}$, and the arch is to the chord as radius to the distance from the centre of the circle to the centre of gravity. The same result will be sufficiently accurate, as applied to the case of a heavy body in the form of a thin flexible prism or parallelopiped, applied to the rim of a wheel, and serves to estimate the momentum of the power in the overshot water wheel.

2. Let the figure represent the Apollonian Parabola, whose equation is $y^2=ax$, or $y=a^{\frac{1}{2}}x^{\frac{1}{2}}$

$$\mathrm{D}=\frac{\int x^{\frac{3}{2}}\dot{x}}{\int x^{\frac{1}{2}}\dot{x}}=\frac{\frac{2}{5}x^{\frac{5}{2}}}{\frac{2}{3}x^{\frac{3}{3}}}=\frac{3}{5}x$$

3. Let the figure represent a segment of a circle of which C is the centre, and AC the diameter which bisects the arch.

$\int yx\dot{x}=\int(r-r+x)\,y\dot{x}=\int ry\dot{x}-\int \dot{r}\ x-x\dot{x})\sqrt{2rx-x^2}=rx$ area ABD $-\ \frac{(2rx-x^2)^{\frac{3}{2}}}{3}=r.$ ABD $-\ \frac{1}{3}\mathrm{BD}^3$, and $\int y\dot{x}=$ ABD. Therefore $\mathrm{D}=r-\frac{\frac{1}{3}\mathrm{BD}^3}{\mathrm{ABD}}$, or the distance from the centre of the circle to the centre of gravity of the segment, is $=\frac{\frac{1}{12}c^3}{a}$, where c is the chord, and a the area of the segment.

Cor. Hence we may find the centre of gravity of a circular sector CEAD. For if t represent the area of the triangle, the sum of the momenta estimated from C or from MN, will be $\frac{2}{3}\mathrm{CB}.\,t+\frac{2}{3}\mathrm{BD}^3=\frac{2}{3}\mathrm{CB}^2.\mathrm{BD}+\frac{2}{3}\mathrm{BD}^3=\frac{2}{3}\mathrm{BD.CD}^2=\frac{1}{3}\mathrm{ED.CD}^2$, which divided by the area of the sector, $=\frac{\mathrm{CD.DAE}}{2}$, gives as the distance from the centre $\frac{\frac{2}{3}\mathrm{CD.ED}}{\mathrm{DAE}}$, or a fourth proportional to the arch, the chord, and two-thirds of the radius. The same result may also be readily obtained in the following manner. Let z' be the arch which measures the angle of the sector to a radius $r'=\frac{2}{3}r$, and let c' be the chord of this arch; conceive the sector to be divided into an indefinite number of sectors indefinitely small, which may be regarded as rectilineal triangles: their centres of gravity will all be in the arch z', and uniformly distributed. Hence, by Ex. 1. the distance from C to the centre of gravity of the whole will be $\frac{r'\,c'}{z'}=\frac{\frac{2}{3}r\,\frac{2}{3}c}{\frac{2}{3}z}=\frac{\frac{2}{3}r\,c}{z}$

4. Let EAD represent the surface of a spherical segment.

We shall then have $\dot{z}:\dot{x}=r:y$ $\dot{z}=r\,\dot{x}$.

Hence $D=\frac{\int y\,x\,\dot{z}}{\int y\,\dot{z}}=\frac{\int x\,\dot{x}}{\int \dot{x}}=\frac{1}{2}x$, and the centre, the point which bisects the altitude of the segment.

5. Let AM and AN be straight lines, and let the figure so changed represent a cone. Let r be the radius of the base, y the radius of a section parellel to the base at the indeterminate distance x from the vertex, and a the altitude of the solid.

$$D=\frac{\int\frac{r^2\,x^3\,\dot{x}}{a^2}}{\int\frac{r^2\,x^2\,\dot{x}}{a^2}}=\frac{\int x^3\,\dot{x}}{\int x^2\,\dot{x}}=\frac{\frac{1}{4}x^4}{\frac{1}{3}x^3}=\frac{3}{4}x=\frac{3}{4}a$$

for the whole cone.

6. Let BAC be a paraboloid, the equation of whose generating curve is $y^2=a\,x$

$$D=\frac{\int x^2\dot{x}}{\int x\,\dot{x}}=\frac{\frac{1}{3}x^2}{\frac{1}{2}x^2}=\frac{2}{3}x$$

7. Let BAC be a segment of a sphere, of which the radius is r. Here $y^2=2\,r\,x-x^2$, and

$$D=\frac{\int(2\,r\,x^2\dot{x}-x^3\dot{x})}{\int(2\,r\,\dot{x}\,x-x^2\dot{x})}=\frac{\frac{2}{3}r\,x^3-\frac{1}{4}x^4}{r\,x^2-\frac{1}{3}x^3}=\frac{(8\,r-3\,x)\,x}{(12\,r-4\,x)}.$$

When the figure of a body or its density is irregular, the centre of gravity is to be found experimentally.

Let the body be suspended, in equilibrio, by a string attached successively to two different points; and that point in which the directions of the string produced would intersect each other, is the centre of gravity.

When we have occasion merely to learn its distance from one of the extremities of a body, it may be balanced upon the edge of a prism, and the centre will then be vertically above that edge: or it may be made to rest upon a prop at the one extremity, while it is balanced in a horizontal position by a weight attached to the other, and acting by a string passing over a fixed pulley. As the momentum of the weight must then be equal to that of the body conceived as acting at the centre, the whole weight of the body will be to the appended weight, as the length of the body between the axis on which one of its extremities rests and the other extremity, is to the distance from the axis to the centre of gravity.

CHAP. II.

ON THE MECHANICAL POWERS.

The *Mechanical Powers* is a name given to the simple machines, by the combination of which all other machines are formed, however simple or complicated they may be. The mechanical powers are seven in number, viz. 1. The lever; 2. The pulley; 3. The wheel and axle; 4. The inclined plane; 5. The screw; 6. The wedge; and 7. The funicular machine.

Def. In the mechanical powers, and in all their combinations, the object of which is in general to keep in equilibrium, or to move one force by means of another which is more powerful, the term *weight* or *resistance* is given to the force which it is required to keep in equilibrium, or to move; and the term *power* is given to the force which is applied to the machine for this purpose.

SECTION I. *On the Lever.*

Def. A lever is an inflexible bar, or rod, either straight or curved, which is capable of moving freely round a fixed point, called its *fulcrum.* The parts of the lever between the fulcrum and the points where the power and the weight are applied, are called its *arms.*

Levers have received different names, according to the relative position of the power, the weight, and the fulcrum. A lever is said to be of the *first kind*, when the power and the weight are on opposite sides of the fulcrum, as in the balance, steelyards, scissars, pincers, &c. In levers of the *second kind*, the weight is placed between the power and the fulcrum, as in cutting instruments, which move round the point of the bla de, and in oars, where the water is reckoned the fulcrum. In levers of the *third kind*, the power is placed between the weight and the fulcrum, as in fire-tongs, and shears used in sheep-shearing.

PROP. I.

In every straight lever devoid of weight, there will be an equilibrium when the power and the weight are reciprocally proportional to their distances from the fulcrum.

This proposition has already been demonstrated in all its cases, under Prop. II. Chap. I. and its Corollaries. Hence, (Plate CCCLXI.

In a lever of the first kind, Fig. 1. P : W=BC : AC
In a lever of the second kind, Fig. 2. P : W=BC : AC
In a lever of the third kind, Fig. 3. P : W=BC : AC

Hence we have $P=\frac{W\times BC}{AC}$, $W=\frac{P\times AC}{BC}$,

$$AC=\frac{W\times BC}{P},\ BC=\frac{P\times AC}{W}.$$

COR. 1. The weight supported by the fulcrum C is obviously equal to the sum of the power and weight, or P+W, when they act on different sides of the fulcrum, and therefore in the same direction; and to the difference P—W when they act on the same side of the fulcrum, and therefore in different directions.

COR. 2. If the power P is shifted along the arm CA of the lever AB, Fig. 1, the weight W which it is capable of keeping in equilibrio will be proportional to CA, the distance of the power P from the fulcrum. For since P : W=BC, AC, we have W : AC=P : BC; and if w be another value of W, and a C another value of AC, we shall likewise have w : a C=P : BC. Hence GEOMETRY, Axiom 3, and Prop III. W : w=A C : aC.

Prop. II.

In bent and crooked levers devoid of weight there will be an equilibrium, when the power and the weight are reciprocally proportional to the perpendiculars let fall from the fulcrum upon the direction in which the power and the weight are applied.

This proposition has also been demonstrated in Cor. 3. of Prop. II. Chap. I.; and hence in the bent lever ACB, (Plate CCCLXI. Fig. 4.) $P : W = b\,C : a\,C$.

Cor. 1. The power and the weight are reciprocally proportional to the sines of the angles which the line of the direction forms with the arms of the lever; for $C\,a$ and $C\,b$ are obviously the sines of the angles $CA\,a$, $CB\,b$, CA and CB being considered as radius.

Cor. 2. The energies of P and W to turn the lever round its fulcrum is obviously the same, at whatever part of the lines of direction $P\,a$, $W\,b$ they are applied; for the perpendiculars $C\,b$ and $C\,a$, to which these energies are proportional, remain the same.

Cor. 3. If AC, (Plate CCCLXI. Fig. 5.) an inflexible bar moving round C as a fulcrum, is acted upon by two forces P and W, in the direction AP, AW, these forces will be in equilibrio, when they are to each other as the perpendiculars $C\,n$, $C\,m$. If we conceive the forces applied at m and n, and consider mCn as a lever, then $P : W = Cn : Cm$ the perpendiculars let fall on the lines of direction.

Prop. III.

In every combination of levers which are made to act perpendicularly upon each other, or at equal angles, and in which the power in the first lever, and the weight in the last lever, act at the same angles that the levers do upon each other, there will be an equilibrium when the power is to the weight as the product of the distances of all the weights is to the product of the distances of all the powers, the weight at the first lever being regarded as the power acting upon the second; and so on.

Let the lever AB (Plate CCCLXI. Fig. 6.) act by its extremity B, with a force M, upon the end a of the second lever $a\,b$, and the end of b of the second lever act upon the point α of a third lever, with the force N. Then we have,

$$P : M = CB : AC$$
$$M : N = c\,b : ac$$
$$N : W = c'\,\beta : \alpha\,c'$$

Hence by composition we have,

$$P : W = CB \times c\,b \times c'\,\beta : AC \times a\,c \times \alpha\,c'.$$

Prop. IV.

In a physical lever of any form, and made of any materials, whether of equal or unequal density, there will be an equilibrium, when the power multiplied by the perpendiculars let fall upon the line of its direction, added to the weight of the arm to which it is applied, multiplied by the horizontal distance of the centre of gravity of that arm from the fulcrum, is equal to the weight multiplied by the perpendiculars let fall upon the line of its direction, added to the weight of the arm to which it is applied, multiplied by the horizontal distance of the centre of gravity of that arm from the fulcrum.

Let AB, (Plate CCCLXI, Fig. 7.) be a heavy lever by the intervention of which the power P and weight W act upon each other. Let m be the centre of gravity of the arm AC, and n the centre of gravity of the arm BC. Then if the lever had no weight, we have $P \times C\,a = W \times C\,b$; but since the lever is supposed to be heavy, we may conceive it divided into two parts at C, and suppose each to be weights m and n acting in the direction of gravity at the centres of gravity m, n. Consequently, if we draw $m\,\mu$, $n\,\nu$ parallel to $A\,a$ or $B\,b$, the force of the arm AC may be represented by $m \times C\,\mu$ and that of BC by $n \times C\,\nu$. The forces therefore acting on one arm of the lever are $P \times C\,a + m \times C\,\mu$, and those acting on the other arm are $W \times C\,b + n \times C\,\nu$; and therefore, when these are equal, or $P \times C\,a + m \times C\,\mu = W \times C\,b + n \times C\,\nu$, there will be an equilibrium, (Cor. 10. Prop. II. Chap. I.)

Prop. V.

To explain the conditions of equilibrium in a balance.

In our article on the Balance, (Plates LI. II.) we have already described the construction and use of some of the best balances at present made use of, and have given all the practical information that can be desired. See also Chemistry, and Plate CXLII. Fig. 7.

The balance is obviously a lever of the first kind, having two equal arms, at the extremities of which two equal scales are suspended. When the weights of the arms and scales on each side of the centre of suspension are exactly equal, and is indicated by the extremities C, C of the beam, (Plate LII. Fig. 1.) pointing to the zero of the divided arcs E, E, it is manifest that the weight of any body, placed in one of the scales, will be found by placing known weights in the other scale, till the index again points at zero. The perfect equality of the two weights thus placed in equilibrio cannot, however, be a matter of certainty, unless we know that the two arms are exactly equal. In order to determine this, we have only to make the weights and the body weighed change places; and if the arms are unequal, there will no longer be an equilibrium. By this means, we only ascertain that the balance is imperfect; but we may, by a very simple process, find the exact weight of any body P by an imperfect balance. For this purpose, let up suppose that the body P, placed in the left hand scale, is exactly balanced by the weight W in the right hand scale. Take out P, and substitute in its place a weight P′ which exactly balances W; then, though, from the known inaccuracy of our balance, P is not equal to W, nor P′ equal to W, yet P is equal to the weight P′, because they are both in equilibrio with the same weight W, in the same circumstances.

The same result may be obtained without two sets of weights, in the following manner: Let W', W'' be the weights of any body P, when weighed in both the scales of an imperfect balance, whose arms are CA, CB, then the real weight of it is $W = \sqrt{W' \times W''}$. For since by the first weighing we have $W' \times CA = P \times CB$, and by the second weighing $W'' \times CB = P \times CA$, then dividing the first equation by the second, we have $\frac{W'}{P} = \frac{P}{W''}$, and consequently $P^2 = W' \times W''$ and $P = \sqrt{W \times W''}$.

Prop. VI.

To explain the construction and use of the steelyard.

The Roman steelyard is an instrument for finding the weights of different bodies by means of a single weight, which is placed at a greater or less distance from its fulcrum, or centre of suspension. It consists of a scale, and sometimes of a hook placed at the end of the shorter arm, CA, (Plate CCCLXI. Fig 8.) for carrying the body to be weighed, and of a weight W, which is made to slide along the longer arm CB. When the body P is suspended at A, the constant weight W is slipped along the arm CB, till the equilibrium is indicated by the tongue or index at C. When this is effected, the number at the point *b* indicates the weight of the body P.

In order to divide the arm CB of the steelyard, let us suppose that M is the weight of the arm CB, united in its centre of gravity μ, N the weight of CA, united in its centre of gravity ν, and O the weight of the scale. Let P, P′, P″, be the different weights which are put into the scale; and let an equilibrium be effected, by placing the constant weight W at the points *a*, *b*, *c*. It therefore follows from Prop. II. Cor. 10, Chap. I. that there will be an equilibrium in these three different cases, when

$$P\times CA+N\times C\,n+O\times CA=W\times C\,a+M\times C\,m$$
$$P'\times CA+N\times C\,n+O\times CA=W\times C\,b+M\times C\,m$$
$$P''\times CA+N\times C\,n+O\times CA=W\times C\,c+M\times C\,m.$$

By subtracting the first equation from the second, and the second from the third, we obtain

$$\overline{P'-P}\times CA=P\times ab$$
$$\overline{P''-P'}\times CA=P\times bc,\text{ and}$$
$$ab=\frac{\overline{P'-P}\times CA}{P}$$
$$bc=\frac{\overline{P''-P'}\times CA}{P},\ \&c.$$

Cor. 1. If the weights P, P, P, &c. are in arithmetical progression, or increase by equal differences, the divisions *a b*, *b c*, &c. will form a scale of equal parts; and if *a b* is taken equal to CA, we shall have $W=P'-P$, $W=P''-P'$, &c. or the counterweight equal to the difference of the arithmetical progression of the bodies weighed.

In constructing a steelyard, it is obvious that the scale must be formed experimentally; and the larger arm should be made so strong, that it will not bend by the greatest weight to which it can be applied.

The Danish and Swedish steelyard is a lever with a constant weight fixed at one extremity, and a scale for holding the body to be weighed at the other extremity. The point of suspension is therefore variable, and is generally a ring, as shewn in Plate CCCLXI. Fig. 9, which is moveable along the lever till an equilibrium takes place. If we suppose the weight W of the whole steelyard, excluding the ring, to be united in its centre of gravity D, and P to be that of the body to be weighed, then there will be an equilibrium when $W\times CD=P\times CB$, which (since $CD=BD-CB$) gives $CB=\frac{W\times BD}{W+P}$, from which the lever may be easily graduated.

The reader will find very copious details in De la Hire's *Traité de Mecanique*, Props. 35, 36, 37, and 38, respecting the graduation of steelyards. For farther information respecting the properties of the lever, see Galileo, *Discursus*, &c. vol. ii. p. 98. Maclaurin's *Account of Newton's Discoveries*. Landen's *Memoirs*. Hamilton's *Essays*, and *Phil. Trans.* vol. xciii. p. 113. Fonceneix, *Miscellan.* Turin. tom. ii. p. 321. D'Alembert, *Mem. Acad.* Par. 1769, p. 283. Æpinus, *Nov. Comment. Petrop.* tom. viii. p. 271. Van Swinden's *Positiones Physicæ*; and Vince, *Phil. Trans.* 1794, p. 3

Sect. II. *On the Pulley.*

The *pulley* is a cylindrical piece of wood or any other hard substance, with a groove cut out of its rim, for the purpose of allowing a rope to pass over it. The cylinder moves round an axis, which works in a frame called the block. A system of pulleys, or a number of them combined together, is called a *muffle*, and is either *fixed* or *moveable*, according as the block which contains the pulleys is fixed or moveable.

Prop. I.

In a simple pulley supposed to be devoid of weight, there will be an equilibrium when each of the two powers is to the weight as the radius of the pulley is to the arch of the circumference of the pulley which is embraced by the rope.

Let the powers P, P′, (Plate CCCLXI. Fig. 10.) acting by the ropes MC, NE, passing over the circles M, N, and round the pulley CGE, whose centre is D, be in equilibrio with the weight W suspended from the pulley, then there will be an equilibrium when $P:P':W=CD:DF,\ CE$. Since the forces P and P are equal, in consequence of their being in equilibrio, we may represent them by the equal lines WA, WB; then drawing AF parallel to MW, and BF parallel to NW, the diagonal WF will represent the resultant of the two powers P, P′; but since this resultant is in equilibrio with the weight W acting in the same direction FW, we shall have FW for the measure of the weight W. If we now join CD, ED, and draw CE, we shall have the two isosceles triangles WBF, CDE similar, because the angles A and D, comprehended between the equal sides, are both the supplement of the same angle CWE, the quadrilateral figure CDEW having its angles of C and E right angles. Hence

$$WB:BF:WF=DC:DE:CE;$$

therefore $P:W$, or $P':W$, as radius is to the chord of the arch embraced by the rope.

Cor. 1. Each of the powers is to the weight as radius is to twice the cosine of the angle which each rope forms with the direction of the weight. As the angle DCH is equal to CWD, CE is equal to twice its cosine, or twice CH.

Cor. 2. When the two cords or ropes are parallel, as in Plate CCCLXI. Fig. 11. there will be an equilibrium if each of the forces or powers P and P′ is one half of the weight or resistance W; for, in this case, the arch embraced by the rope is 180°, the chord of which is equal to twice the radius, and therefore each of the powers is only one half of the resistance.

Cor. 3. When one of the cords is fixed, as at H, Fig.

H, then we have only one power P in action, and, as the fixed hook H supports what was formerly supported by P′, the remaining power P will keep the resistance in equilibrio when it is equal to $\frac{1}{2}$ W.

Cor. 4. When the pulley is heavy, and acts in the same direction as the resistance, we must consider the weight of the pulley as part of the resistance, and therefore the resistance will be that determined in the proposition diminished by the weight of the pulley. If the direction of the resistance is different from that of gravity, in which the weight of the pulley acts, we have only to form a parallelogram, of which one side expresses the weight of the pulley, and the other the resistance found by the proposition, and the diagonal will represent the real resistance and its direction, which will be greater or less than the other resistance, according as the direction of gravity coincides with, or opposes that of the resistance.

Prop. II.

To determine the ratio of the power to the resistance, when there is an equilibrium with any number of moveable pulleys.

Let D, D′, D″, be a system of moveable pulleys, the first of which carries a weight W, and let a cord, fixed at M, pass round D, and be attached to the block of the second pulley D′; let another cord, fixed at N, pass round the second pulley D, and be fixed to the third pulley D″; and, in like manner, let another rope, fixed at O, pass round D″, and have a power P applied to it. Now the cord CD′ is evidently stretched with a force, which is to W as CE : CD, and is therefore equal to $P\times\frac{CE}{CD}$. For the same reason the force with which C′D″ is stretched, is equal to $P\times\frac{CE}{CD}\times\frac{C'E'}{C'D'}$, and the force with which C″P is stretched is $P\times\frac{CE}{CD}\times\frac{C'E'}{C'D'}\times\frac{C''E''}{C''D''}$. Hence there will be an equilibrium when $W=P\times\frac{CE}{CD}\times\frac{C'E'}{C'D'}\times\frac{C''E''}{C''D''}$, or when the weight is to the power as the product of all the chords of the arches is to the product of all the radii.

Cor. 1. When the ropes are parallel, as in Plate CCCLXI. Fig. 13. the chords are equal to twice the radius, or CE=2CD, and therefore there is an equilibrium when $W=P\times\frac{2CE}{CD}\times\frac{2CE}{CD}\times\frac{2CE}{CD}$; or calling CD=1, $W=P\times 2\times 2\times 2$. Hence it follows, that if n be the number of moveable pulleys, there will be an equilibrium when $P : W = 1 : 2n$.

Prop. III.

To determine the ratio of the power to the resistance, when there is an equilibrium with any number of fixed and moveable pulleys, and when the cords are parallel.

Let Plate CCCLXI. Fig. 14. represent a *muffle* of pulleys, consisting of three fixed pulleys attached to the block MN, and three moveable ones attached to the block RS. A cord suspending the power P passes over all the pulleys, in the way represented in the figure, and is attached to the lower extremity N of the block MN, while the resistance, or weight W, is attached to the lower end S of the moveable block RS, and is supposed to comprehend the weight of the moveable block with its three pulleys, and of the ropes which join them to the fixed pulleys. Then, since the ropes BV, CT make part of the same rope, they must be equally stretched by the weight W; for it is impossible to conceive a rope stretched unequally in different parts of its length. For the same reason, all the other parallel ropes, DL, EK, FH, GN, must be equally stretched, or must bear equal portions of the weight W. Consequently each rope must bear a part of the weight equal to one-sixth W; and therefore, since the rope BV is drawn downwards with the force of $\frac{1}{6}$ W, there will be an equilibrium if it is drawn upwards by means of the rope AP, with a force $P=\frac{1}{6}$ W. The force P, therefore, is capable of balancing a resistance of 6 W by the intervention of this muffle of pulleys. Hence it follows, that there will always be an equilibrium when the weight is to the power, as the number of ropes which draw the lower muffle is to unity.

Cor. There is the same proportion between the power and the resistance when the pulleys are in different planes, as in Plate CCCLXI Fig. 15, or when all the fixed pulleys are placed on one axis, and all the moveable ones upon another, as in Fig. 16. In Fig. 15. the pulleys have all the same diameter. In Fig. 16. they diminish in arithmetical progression, as in Fig. 14.

Prop. IV.

In a combination of moveable pulleys, whose number is n, suspended by separate and parallel ropes, the extremities of each of which are attached to the weight, there will be an equilibrium when $P : W = 1 : 2^n - 1$.

In this combination, which is represented in Plate CCCLXI. Fig. 17. a rope attached to the weight at F passes over the pulley C, and is attached to the block of the pulley B; another rope attached at E passes over B, and is similarly fixed at A; and a third rope attached at D passes over A, and carries the power P.

The rope DA obviously sustains a weight equal to P, since they are in equilibrium. Hence the string AB sustains a weight equal 2 P; and EB, which is in equilibrium with it, a weight also equal to 2 P. The rope BC will therefore draw down with a force equal to $2P+2P=4P$; and FE must sustain a weight 4 P, since it balances BC. The whole weight W, therefore, which is sustained, will be $W=P+2P+4P$, &c. which gives $P : W = 1 : 1+2+4$, &c. to n times; or as $1 : 2^n - 1$.

Prop. V.

In the combination of pulleys represented in Plate CCCLXI. Fig. 18. in which two pulleys are supported by one rope, there will be an equilibrium when $P : W = 1 : 4$.

In this combination of pulleys, which is called a Spanish barton, the rope AP, by which the power P is supported, passes over the moveable pulley A, and round CG towards H, where it is fixed. Another rope fixed to the block of the pulley A passes over BD, and is fixed at E to the block of the pulley CG. Now, as the rope AP supports a weight equal to P, the rope CA must also support a weight equal to P, and the rope AB a weight equal to 2 P. But the rope GH connected with CA is stretched with a force equal to P, and the rope DE is pulled upwards with a force equal to 2 P. Hence it follows, that since AC is pulled upwards with a force equal to P, GH with a force equal to P, and DF with a force equal to 2 P, the pulley CG will be drawn upwards with a force $W=P+P+2P=4P$. Consequently $P:W=1:4$.

PROP. VI.

In the combination of pulleys, represented in Plate CCCLXI. Fig. 19. in which two pulleys are supported by one rope.

In the combination of pulleys shewn in Fig. 19, and likewise called a Spanish barton, the rope PB passing round B, and then round C, is fixed at E to the block of B. A second rope fixed to the block at B passes over A, and is attached at I to CD, the pulley which carries the weight W. It is obvious that the ropes GC and DE, like PB, are each stretched with a weight equal to P. But the rope BA, and consequently FI, is stretched with a force $=3P$, because the three ropes BP, GC, ED, are each stretched with a force $=P$. It follows, therefore, that the pulley CD is drawn upwards with a force $W=P+P+3P=5P$. Hence $P:W=1:5$.

SECT. III. *On the Wheel and Axle.*

The *wheel and axle*, otherwise called the *axis in Peritrochio*, which we have represented in Fig. 1. of Plate CCCLXII. consists of a cylindrical axis CD, of any diameter, to which is fixed a wheel AB, of a greater diameter, and having its centre coincident with the axis of the cylinder, and its plane perpendicular to this axis. This axle moves upon pivots at C and D, fixed to an immoveable frame, so as to allow the wheel to turn freely about its axis. The power is generally applied to the circumference of the wheel by means of a rope, which lies in a groove in the wheel's circumference, one end of it being fixed to the circumference, and the other to the power P. The resistance to be overcome, or the weight to be raised, is generally supposed to be a weight W suspended at the extremity of the cord WF, and coiled round the axle between E and F. The axle CD is supposed to be horizontal.

PROP. I.

In the wheel and axle there will be an equilibrium, when the power is to the weight as the radius of the axle is to the radius of the wheel.

In Plate CCCLXII. Fig. 2. let AB be the axle, OH the wheel, and W the weight applied to the point E, and let the power P be applied to the point M in the direction MC. Let O be the centre of the wheel, and K that of the axle. Through E draw a plane perpendicular to the axis AB, cutting it at K, and therefore the radius KE of the cylinder will be a horizontal line, or perpendicular to the vertical EW, since EW touches the cylinder at E. Through O, the centre of the wheel, draw OF, another radius of the cylinder, parallel to KE, and on the opposite side of the axis. This radius will likewise be horizontal, and in the plane of the wheel. Let two forces W', W'', each of which is equal to W, be applied in opposite directions to the point F, and in the vertical line GH, the one W' acting in the direction FG, and the other W'' in the direction FH. As these two opposite forces destroy each other, the equilibrium of the machine will not be affected by their application. Join FE, meeting the axis in D, and bisecting KO in D, because $KE=FO$; and let us consider the state of the forces W acting at E, and W' acting at F. Since $W'=W$, the effect of these forces will be the same as 2 W acting at D; but as the point D is in the axis of the cylinder, which axis is immoveable, the force 2 W can have no effect in altering the equilibrium of the machine, or turning it round its axis. The remaining forces, therefore, are P applied at M, and W'' applied at F, and acting in the direction FH. But we may consider MOF as a bent lever whose fulcrum is O, and therefore since the forces applied at M and F in directions MC, FH perpendicular to the arms of the lever are in equilibrio, these forces will be inversely as the lengths of the arms, that is $P : W''=OF : OM$, but since $FO=EK$, and $W''=W$, we have $P : W=EK : OM$.

Hence it follows, that when there is an equilibrium in the wheel and axle, *the power is to the weight as the radius of the axle is to the radius of the wheel.*

In the wheel and axle the power is sometimes applied to a series of spokes standing vertically out of the rim of the wheel, and sometimes to a winch or handle, which is substituted in place of the wheel; but in all these cases the ratio between the power and the weight remains the same, provided that they are always applied at right angles to the radius.

As the ropes by which the power and weight are applied to the machine must have a sensible diameter, the radii of the wheel and the axle must both be increased by the semidiameter of the rope.

COR. 1. If the power and weight act obliquely to the radius, the power will be to the weight inversely as the perpendiculars let fall from the centres of the wheel and the axle upon the lines of their direction. As these perpendiculars are a maximum when the power is applied in a tangential direction, this is therefore the most advantageous way in which it can be applied.

COR. 2. If the wheel is not placed exactly perpendicular to the axle, the power will be to the weight as the radius of the axle to the co-sine of the deviation of the wheel from the perpendicular.

When the axle is placed vertically, and spokes or levers are applied to it in place of the wheel, the machine is commonly called a *Capstane*, which is represented in Plate CCCLXII. Fig. 3.

PROP. II.

To determine the pressures which the power and weight exert upon the pivots A and B of the wheel and axle.

In order to determine the pressures which the two powers P and W exert upon the pivots A, B, we may substitute in place of the force W acting at E, a force 2 W acting at D, and a force $W''=W$ acting at the point F in a direction opposite to that of gravity. But as the resultant of the forces P and W'' passes through the point O, we may transfer them to this point, parallel to their directions, so that if we draw through the point O the line OC′ and OH′ parellel to MC and FH, we may suppose the force P to act in the direction OC′, and the force W″ or W in the direction OH′. Hence, instead of the two given forces P and W applied at M and F, we shall have three forces 2 W, P and W applied at the two points D and O of the immoveable axis of the cylindrical axle. We have therefore only to decompose each of these three forces into two others parallel to its direction, and passing through the points A and D, and then reducing to a single force the three constituent forces relative to each of the points A and B, we shall have the magnitude and direction of the pressure which they support. If the power P is a weight acting by its gravity, the pressure will be vertical upon both pivots, the parallel lines MC, OC′ will be vertical; the two forces W and P applied at O will be equal to the single force W—P acting in the direction OH′, and the pressure on each of the pivots A, B will be equal to the constituent of the force 2 R, *minus* the constituent of the force W—P relative to each pivot.

In order to calculate these pressures, let

$a =$ length of cylinder AD,

$b =$ OB, the distance of the wheel's centre from the point B,

$x =$ KB, the distance of the point of application of the weight W, from the same point B, which may vary for the same wheel and axle.

Then we shall have

$$x - b = \mathrm{KO}$$
$$\tfrac{1}{2}x - \tfrac{1}{2}b = \mathrm{OD}$$
$$\tfrac{1}{2}x + \tfrac{1}{2}b = \mathrm{BD}$$
$$a - \tfrac{1}{2}x - \tfrac{1}{2}b = \mathrm{AD}.$$

Let U and V be the constituents of the force 2 W, parallel to the direction H, the first U passing through the point A, and the second V, through the point B, then we shall have

$\mathrm{U} : 2\,\mathrm{W} = \mathrm{DB} : \mathrm{AB}.$

$\mathrm{V} : 2\,\mathrm{W} = \mathrm{DA} : \mathrm{AB}.$ But if we substitute for DB, DA and AB, their values as given above, we shall obtain

$$\mathrm{U} = \frac{\mathrm{W}\,(b+x)}{a}, \qquad \mathrm{V} = \frac{\mathrm{W}\,(2\,a - b - x)}{}$$

If we call U′ and V′ the constituents of the force W — P applied to the points A and B, we shall have

$$\mathrm{U}' = \frac{(\mathrm{W} - \mathrm{P})b}{a}, \qquad \mathrm{V}' = \frac{(\mathrm{W} - \mathrm{P})\,(a - b)}{a}.$$

Wherefore, if we represent by X, Y, the vertical pressure exerted on the fixed supports AA′ and BB′, we shall have first X = U — U′, and Y = V—V′, and substituting for these symbols their proper values, and then reducing, we obtain

$$\mathrm{X} = \frac{\mathrm{W}\,x + \mathrm{P}\,b}{a} \qquad \mathrm{Y} = \frac{\mathrm{W}\,(a - x) + \mathrm{P}\,(a - b)}{a}.$$

If we wish to take into account the additional pressure exerted by the weight of the wheel and axle, we must consider the weight of the cylindrical axle as a vertical force applied to its centre of gravity, or to the middle of AB; and the weight of the wheel as a vertical force applied to its centre of gravity O. If we then represent these two weights by w' and w'', and decompose each of them into two others applied to A and B, we shall find that the value of X must be augmented by the quantity $\frac{1}{2}w' + \frac{w''b}{a}$, and that of Y by the quantity $\frac{1}{2}w' + \frac{w''(a-b)}{a}$; and therefore the complete value of X and Y will be,

$$\mathrm{X} = \frac{\mathrm{W}x + (\mathrm{P} + w'')b}{a} + \tfrac{1}{2}w', \text{ and}$$
$$\mathrm{Y} = \frac{\mathrm{W}(a - x) + (\mathrm{P} + w'')\ (a - b)}{a} + \tfrac{1}{2}w'$$

In demonstrating these two propositions, we have followed implicitly M. Poisson. Bossut had previously given a similar, but a less perspicuous, investigation of the pressures upon the pivots A and B, in his *Traité de Mecanique*, p. 131—137. Edit. Paris, 1802.

Prop. III.

To determine the conditions of equilibrium in a machine composed of several wheels and several axles, which have a common axis.

If R, R′, R″ represent the radii of the wheels acted upon by powers P, P′, P″, and *r*, *r*′, *r*″ the radii of the axles acted upon by weights W, W′, W″; then since the sum of the momenta of the powers, which are exerted in turning the wheel in one direction, must, in the case of an equilibrium, be equal to the sum of the momenta of those weights which are exerted in turning the machine in the opposite direction, we shall have

$$\overline{\mathrm{P}\times\mathrm{R}} + \overline{\mathrm{P}'\times\mathrm{R}'} + \overline{\mathrm{P}''\times\mathrm{R}''} = \overline{\mathrm{W}\times r} + \overline{\mathrm{W}'\times r'} + \overline{\mathrm{W}''\times r''}.$$

Prop. IV.

In a machine composed of several wheels and axles connected together by ropes, which pass from the wheel of the one to the axle of the other, the power is to the weight as the product of the radii of all the axles is to the product of the radii of all the wheels.

Let there be three wheels AB, A′B′, A″)B″ (Plate CCCLXII. Fig. 4.) and three axles CN, C′N′, C″N″. Let the power P be applied to a cord or rope PN, passing over the axle CN. Let another rope be coiled round AB, so as to touch it at M, and pass round the axle C′N′ of the wheel A′B′. Let a third rope, coiled round A′B′, pass from the point of contact M′ to the axle C″N″ of the third wheel AB; and let a fourth rope, coiled round this third wheel, carry at its extremity the weight W. Let P′ be the weight which the power P could raise, or the force which it could exert in the direction MN′), by means of the first wheel and axle; and P″ the force with which W will be in equilibrio, by the intervention of the second wheel and axle A′B′; and W the final weight, or the force which will be in equilibrio with P, by the intervention of the third wheel and axle A″B″. Then calling R, R′, R″ the radii of the wheels, and *r*, *r*′, *r*″) the radii of the axles, we shall have by Prop. I. of this Sect.

$$\mathrm{P} : \mathrm{P}' = \mathrm{CN} : \mathrm{CM} = r : \mathrm{R}$$
$$\mathrm{P}' : \mathrm{P}'' = \mathrm{C'N'} : \mathrm{C'M'} = r' : \mathrm{R}'$$
$$\mathrm{P}'' : \mathrm{W} = \mathrm{C''N''} : \mathrm{C''M''} = r'' : \mathrm{R}''$$

These analogies being multiplied term by term, give

$$\mathrm{P} : \mathrm{W} = r \times r' \times r'' : \mathrm{R} \times \mathrm{R}' \times \mathrm{R}'';$$

that is, the power P is to the weight W as the product of all the radii of all the axles is to the product of the radii of all the wheels.

On Toothed Wheels.

It is obvious, that in the preceding proposition the ratio of the power to the weight will remain the same, whatever be the way in which the axle C′N′ has its force conveyed to the wheel AB. Let us suppose that the surface of the pinion C′N′, and that of the wheel AB, is so rough, that when they are in contact the one will move the other, or that sharp points in the pinion take hold of the circumference of the wheel; or, what is the same thing, that teeth, or projecting points, in the one, lay hold of other teeth, or projecting points, in the other; then, in all these cases, the ratio of the power to the weight is the same. In this last case, which we have represented in Fig. 4. the projecting points are called *teeth*, and the wheels *toothed wheels*, and the axles *pinions*.

In Plate CCCLXII. Fig. 5. the system of toothed wheels has all the axles parallel, and the teeth are prolongations of the radii of the wheel, and lie in its plane. In Fig. 6. the teeth of the pinions only are prolongations of the radius. The teeth of the wheels are perpendicular to the radius, and the axles lie in a different direction. In large wheels, the pinions have the form shewn in Fig. 7. and are thence called *lanterns*, and the cylindrical teeth *trundles* or *spindles*.

In these various combinations, and in others of a more complicated nature, the machines may always be considered as a combination of wheels and axles, and *the power will always be to the resistance as the product of the radii of all the pinions is to the product af the radii of all the wheels.*

The reader who is desirous of pursuing this subject, will find some very interesting problems of a practical nature on toothed wheels, in Bossut's *Traité de Mecanique*, p. 140; Camus' *Cours de Mathematique*, liv. x. and xi.; and in Berthoud's *Traité d'Horlogerie*.

SECT. IV. *On the Inclined Plane.*

The *inclined plane* is any plain surface which forms an angle with the horizon. The *inclination of the plane* is the angle which its upper surface forms with the horizon, and is measured by ABC. (Plate CCCLXII. Fig. 8.) The line AB is called the *length* of the plane, BC the length of its base, and CA its *height*. This mechanical power is generally employed to keep in equilibrium a heavy body, by means of a force which has not a vertical direction. In Fig. 8. for example, if the body D is to be raised through the height CA by the power of a man directly, he must support the whole of its weight; but by laying it upon the inclined surface BA, a considerable part of its weight will be supported by the plane, and he will be able to roll it up to the top A by an oblique force.

PROP. I.

In an inclined plane there will be an equilibrium when the power is to the weight as the height of the inclined plane is to the length of its base, multiplied by the cosine of the angle which the direction of the power makes with the inclined plane.

When a body W (Plate CCCLXII. Fig. 8.) is placed upon a horizontal plane, it is obvious that it cannot be in equilibrio, unless a perpendicular let fall from its centre of gravity, cuts the plane within the base of the body. When the plane becomes inclined to the horizon, the same condition is necessary, and another force P is requisite to prevent it from sliding down the plane in virtue of its gravity. In order that an equilibrium may take place, the resultant of the two forces P and W must be in a line perpendicular to the plane, and their directions must lie in the same plane; and as the direction of W is in a vertical plane passing through the centre of gravity of the body, the direction of P must be in the same plane. Let *a b c d*, therefore, be a section of the body W, and ABC a section of the inclined plane, by a vertical plane passing through the centre of gravity D of the body, and let AC be a vertical, and BC a horizontal line. Let DF be the direction of the force or weight W, and DE the direction of the force P, by which W is held in equilibrium, D the point of their intersection, and DG a perpendicular let fall from that point upon the plane AB.

Since DG is the direction of the resultant of the forces P, W, acting in the directions DE and DF, we shall have by Cor. 8. of Prop. I. Chap. I. $P : W = \sin. FDG : \sin. EDG$. But since $FDG = ABC$, we have $\sin. FDG = \sin. ABC = \frac{AC}{BC}$. Hence we have $P : W = \frac{AC}{BC} : \sin. EDG$, and multiplying by BC, we obtain $P : W = AC : BC \times \sin. EDG$. But EOA, the angle which the direction of the force ED makes with AB, is the supplement of EDG, since DGO is a right angle; hence $\cos. EOA = \sin. EDG$, and

$$P : W = AC : BC \times \cos. EOA;$$

that is, the power is to the weight as the height of the plane is to the length of its base, multiplied by the cosine of the angle which the direction of the power forms with that of the plane.

COR. 1. When the power P is applied in a direction parallel to the plane BA, the angle EOA vanishes, and its cosine is 1. Hence we have $P : W : AC : BC$; that is, the power is to the weight as the height of the plane is to the length of its base.

COR. 2. The power being applied, as in Cor. 1. it is obvious that the power must be less than the weight when $AC < BC$, and greater than the weight when $AC > BC$; that is, the inclined plane is favourable or unfavourable to the power, according as its inclination is less or greater than 45°.

PROP. II.

If a body, influenced only by gravity, is in equilibrium between two inclined planes, the pressures upon the planes will be reciprocally proportional to the sines of their inclination to the horizon, and the absolute weight of the body will be represented by the sine of the angle formed by the two planes.

Let ABC, A′BC′, be the two inclined planes, and D a heavy body placed upon them, and in a state of equilibrium. The weight of that body is exerted in the vertical line DF, passing through its centre of gravity D, and must be equivalent to two forces passing through the points of support E and G, and perpendicular to the two inclined planes AB, A′B. As the three forces, therefore, DE, DF, DG, meet in the same point D, and lie in the same plane, which is a vertical one, and perpendicular to each of the inclined planes, because it contains the vertical line DF, and the two lines DE, DG perpendicular to the inclined planes, it follows that the common sections of the two planes is a horizontal line, and that the body D cannot remain in equilibrio, unless the two planes which support it have their common sections horizontal, and unless its weight is resolved into two forces perpendicular to the points of support. Through A′ draw the horizontal line A′H, meeting AB in H; then it is obvious by Prop. I. of this section, and Cor. 8. Prop. I. Chap. I. that the three forces DF, DE, DG, are to one another as sin. GDE or GBE, sin. GDF and sin. EDF, or as the sides DF, FG, DG; that is, on account of the similar triangles DGF, A′BH, as A′H, A′B and BH; hence DF : DE : DG = AH′ : A′B : BH. But since the sides of the triangle A′HB are as the sines of the opposite angles, we have DF : DE : DG = sin. HBA′ : sin. ABC : sin. A′BC′; that is, the weight which was represented by DF is represented by the sine of the mutual inclination of the two planes, and the pressures upon each plane are reciprocally proportional to the sines of their inclination to the horizon.

Cor. 1. When the mutual inclination of the planes ABA′ is a right angle, the pressure against one of the planes is to the weight as the sine of the inclination of the other plane is to radius, or as the height of the same plane is to its length. This follows from the case of Prop. I. of this section, when the power acts parallel to the plane; for the pressure against the first inclined plane performs the same part with regard to the second as a power acting in the opposite direction, and parallel to the length of the second plane.

Cor. 2. When one of the planes is horizontal, the pressure upon it will be equal to the whole weight of the body, and that upon the other plane will vanish.

When a body rests upon more than two inclined planes, the common sections of these planes may have different positions with regard to the horizon; and the investigation of the pressures upon the planes is no longer a determinate problem, if we adhere strictly to the ordinary principles of mechanics. If the question, however, is simplified, by supposing a body to rest upon three points in a horizontal plane, these points not being in a straight line, the pressure may be determined by the following theorem, which was first given by Euler, in a memoir entitled *De pressione ponderis in planum cui incumbit*, printed in the *Mem. Acad. Petrop.* for 1763, tom. 18. The demonstration is taken from Bossut.

Let ABC, (Plate CCCLXII. Fig. 10.) be three points of support. Join AB, AC, BC, and suppose that a perpendicular, let fall from the centre of gravity of the body, cuts the horizontal plane ABC in P. Draw APD, PB, and PC. Let W be the weight of the body, and x, y, z, the three unknown pressures upon the three points A, B, C. If we now resolve the weight or force W into two other vertical forces which pass through the points A and D, the force passing through A will be $\frac{\mathrm{W}\times\mathrm{DW}}{\mathrm{AD}}$, which will represent the pressure upon A. Hence $x = \frac{\mathrm{W}\times\mathrm{DW}}{\mathrm{AD}}$. The second which passes through D will be $\frac{\mathrm{W}\times\mathrm{AP}}{\mathrm{AD}}$; and if we resolve it into two other forces, which pass through the other points of support B, C, and which will therefore express the pressures upon these points, we shall have $y = \frac{\mathrm{W}\times\mathrm{AW}}{\mathrm{AD}} \times \frac{\mathrm{DC}}{\mathrm{BC}}$, and $z = \frac{\mathrm{W}\times\mathrm{AW}}{\mathrm{AD}} \times \frac{\mathrm{DB}}{\mathrm{BC}}$. Hence $\mathrm{W} : x : y : z = \mathrm{W}\,\frac{\mathrm{W}\times\mathrm{DW}}{\mathrm{AD}} : \frac{\mathrm{W}\times\mathrm{AW}}{\mathrm{AD}} \times \frac{\mathrm{DC}}{\mathrm{BC}} : \frac{\mathrm{W}\times\mathrm{AW}}{\mathrm{A}} \times \frac{\mathrm{DB}}{\mathrm{BC}}$, or $\mathrm{W} : x : y : z = \mathrm{BC}\times\mathrm{AD} : \mathrm{BC}\times\mathrm{DW} : \mathrm{AW}\times\mathrm{DC} : \mathrm{AW}\times\mathrm{DB}$. But since the two triangles ABC, WBC, which have the same base BC, have heights which are as the lines AD, WD, we shall have ABC : WBC = BC × AD : BC × WD, and, for the same reason, WBC : WDC = BC : DC, and WDC : WAC = WD : AW. Hence, if we write these proportions above one another, and multiply them in their order, we shall have WBC : WAC = BC × WD : DC × AW, and, in like manner, WBC : WAB = BC × WD : AW × DB. Consequently $\mathrm{P} : x : y : z = \mathrm{ABC} : \mathrm{WBC} : \mathrm{WAC} : \mathrm{WAB}$.

When the three points of support A, B, C, are in a straight line, the triangles ABC, WBC, WAC, WAB vanish, and the ratio of the forces W, x, y, z, cannot be determined. See D'Alembert's *Opuscules*, tom viii. p. 36.

If the body is supported by more than three points, the problem is necessarily indeterminate, whatever be the position of these points. In order to render it determinate in general, Euler considers the plane upon which the points of support rest as formed of soft clay, and supposes that the pressures of the points of support are proportional to the quantities or depths to which the feet of the body sink in the clay.

Sect. V. *On the Screw.*

The screw consists of a right cylinder of wood or metal, having a rectangular or a triangular prism wrapped or coiled round it, in such a manner that one of the faces of the prism is applied to the convex or concave surface of the cylinder, and one of the sides of the prism always forms an acute angle with the axis of the cylinder, this angle being every where the same.

In order to form a correct idea of the formation of the screw, let AD (Plate CCCLXII. Fig. 11.) be a smooth cylinder, and let $a\,b\,c\,d$ be a portion of a thickness equal to the required depth of the threads of the screw unfolded from its surface, so that when it is again replaced round the cylinder the faces $a\,d$, $b\,c$, may meet and unite in a plane passing through the axis of the cylinder. Divide $a\,d$ into any number of equal parts, and $b\,c$ into the same number, and draw the lines $d\,e$, $g\,f$, $h\,b$. On each side of these lines draw other lines $h'\,b'$, $g'f'$, and $d'\,e'$, parallel to one another, and equidistant from $d\,e$, $g\,f$, by planes perpendicular to the surface, so as to embrace a space equal to the breadth of each thread. If we now wrap this solid rectangle round the cylinder, so that every part of it occupies the same situation as before it was unfolded, and suppose the parts $a\,h\,b$, $h'\,b'\,f\,g$, $g'\,f'\,e\,d$, and $d'\,e'\,c$, to be cut away, leaving only the parts included between the parallel lines, we shall then have a rectangular prism wrapped round the cylinder. The end e of the portion $d\,e$ will obviously join exactly to g, and the end f to h, and these portions will form a regular spiral or thread. Any of the portions $d\,e\,e'\,d'$, $g\,f\,f'\,g'$ or $h\,b\,b'\,h'$, is called a *thread*, because it goes once round the cylinder; and the spaces $c\,e$, $e\,f$, $f\,b$, are called the *distance of the threads*. A screw thus formed is represented in Plate CCCLXII. Fig. 12. and is called a *male* screw with rectangular threads.

If the planes by which the portions $d' e' c$, &c. are supposed to be cut out or removed, are not perpendicular to the plane $a\ b\ c\ d$, but are equally inclined to it, and meet at its outer surface, the thread which is left will be triangular, as is shewn in Fig. 13.

When the screw is formed on the inner surface of a hollow cylinder, it is done in a similar manner, with this difference only, that we must now suppose the threads $d\ e$, $g\ f$, to be cut out and removed, and the portions $d' e' c$, &c. to remain. Instead of being a solid prism, therefore, wrapped round the circumference, it is a rectangular or a triangular groove rising spirally round that circumference. In this case it receives the name of the *female* screw. Hence it is obvious that if a male and female screw are made of the same dimensions, the elevated thread of the former will enter the grooved thread of the latter, and whichsoever of them is fixed, the other may be made to advance upon it by turning about its axis. Two female screws are shown in Plate CCCLXII. Figs. 14, 15.

In considering the screw as a mechanical power, we must regard the male screw as fixed, and carrying a female screw, which constitutes the weight or resistance when it acts by its own gravity, or carries a load. A lever is generally inserted through a square opening in the head of the male screw, and the power is applied to the end of the lever.

PROP. I.

In the screw, an equilibrium will take place when the power is to the weight as the distance between the threads of the screw is to the circumference of a circle, whose radius is the distance of the point of application of the power from the axis of the screw.

Let AB be a fixed screw, (Plate CCCLXII. Fig. 16.) and CD a female screw, which is made to rise upon the male screw by the lever DE, fixed into the female screw at D. We may consider the mass CD as a weight W rising along the inclined face of the screw by a power P, applied at F, and acting in a horizontal plane. Now, since the weight CD or W is sustained by the threads of the male screw, we may conceive that this weight is distributed over various points of the screw with which it is in contact, and therefore divided into small elementary weights, one of which is w. In like manner, we may conceive the power P divided into the same number of elementary powers p, acting parallel to one another, and by means of which a weight w is kept in equilibrio.

We may now conceive the surface of the thread of the screw as divided into an infinite number of portions by horizontal planes, or, what is the same thing, into an infinite number of small inclined planes, whose inclination to the horizon is the same, namely, $e\ d\ c$, Fig. 11. and is equal to the complement of the inclination of the surface of the threads to the axis of the cylinder. We have now, therefore, to determine the ratio of p to w upon a plane of this inclination, the power p being supposed to act parallel to the base of the plane. Let B be the length of its base, and H its height. Then we have $p : w = \mathrm{H} : \mathrm{B}$. But since a single thread of the screw combines an infinite number of these elementary inclined planes, and as the sum of all these bases is equal to $a\ b$, Fig. 11. or the circumference of the cylinder, while the sum of their heights is equal to $c\ e$, the distance between the threads, we shall have $\mathrm{H} : \mathrm{B} = c\ e : c\ d$, and $p : w = c\ e : c\ d$, and $w = \frac{p \times c\ d}{c\ e}$. If we now suppose that the weight w, instead of being supported by the power p, is supported by elementary powers π, π, composing a power Π, and acting at the end E of the lever OE, then, since both the powers p, π, are in equilibrio with w, we may consider them as applied to the points w and E of the lever OE, whose fulcrum is G. Hence $\pi : w = \mathrm{O}\ w : \mathrm{OE}$. But since the circumferences of circles are as their radii $\pi : w = \text{Circ. O}\ w : \text{Circ. OE}$; by multiplying, therefore, this analogy by the former, viz. $p : w = c\ e : c\ d$; and considering that $\text{Circ. O}\ w = c\ d$, we obtain $w : \pi = \text{Circ. OE} : c\ e$, and $w = \frac{\pi \times \text{Circ. OE}}{c\ e}$; and as the same is true of all the other elementary powers and weights, we have $w' = \frac{\pi' \times \text{Circ. OE}}{c\ e}$, $w'' = \frac{\pi'' \times \text{Circ. OE}}{c\ e}$, &c. Hence adding these equations, and considering that $w + w' + w''$, &c. $= \mathrm{W}$, and $\pi + \pi' + \pi'' = \Pi$, we shall have

$$\mathrm{W} = \frac{\Pi\ \text{Circ. OE}}{c\ e};$$

that is, the power is to the weight as the distance between the threads of the screw is to the circumference of a circle, whose radius is the distance of the point of application of the power from the axis of the screw.

COR. Hence it follows, that the power of the screw increases as the distance between the threads diminishes.

DEF. A screw is called an endless screw when it works in a toothed wheel, as shown in Plate CCCLXII. Fig 17. The power applied to the handle H draws the male screw CD, the threads of which cut at A, upon the teeth of the wheel AB. When a common screw raises a weight, as in Fig. 16. the operation terminates as soon as the body CD reaches the end of the screw; but in the present case, the effect of the screw is merely to turn the fixed wheel round its axis, so that the operation never terminates, and hence it is called an endless screw.

PROP. II.

In the endless screw there will be an equilibrium when the power is to the weight as the distance of the threads, multiplied by the radius of the axle, is to distance of the power from the axis of the screw, multiplied by the wheel's radius.

Let the screw CD, Fig. 17. be employed in raising a weight W, attached to a rope coiled round the axis of the wheel AB, by means of a power P applied at H. The whole being supposed in equilibrium, it is obvious that the whole power of the screw is exerted upon the acting tooth of the wheel. Let this power be called p. Then we have by the last Prop. P : p = distance of threads of screw : circ. DH. But the power p is obviously applied to the teeth of the wheel in the direction of the tangent; and therefore we have p : W = rad. of axle : rad. of wheel. Consequently, multiplying these analogies, we have P : W = distance of threads of screw × rad. of axle : circ. DH × rad. of wheel.

A new method of applying screws has been proposed by Mr. W. Hunter, and fully described in the *Phil. Trans.* for 1781, vol. lxxi. p. 58. Let the screw CD, (Plate CCCLXII. Fig 18.) have a number of threads in an inch equal to a, work in a plate of metal AB. Within the male screw CD there is formed a female screw, which receives the smaller screw DE, which has $a+1$ threads in an inch. The apparatus AFGB prevents the screw DE from turning round along with CD. If the handle CKL is now turned a times round, the screw CD will rise through the height of an inch, and if DE is supposed to move along with it, the point E will likewise rise an inch. If the screw DE is now turned a times backward, the point E will descend $\frac{a}{a+1}$ of an inch, and the result of both these opposite motions will be to cause the point E to rise $1-\frac{a}{a+1}=\frac{1}{a+1}$ of an inch. But if DE is prevented from moving when CD is turned a times round, the effect will be the same as if it had moved a times round with CD, and had been a times turned back; that is, it will advance $\frac{1}{a+1}$ of an inch. By one turn of the handle CKL, therefore, it will move upwards $\frac{1}{a+1}\times\frac{1}{a}=\frac{1}{a^2+a}$ of an inch. Hence, if b is the length of the handle CK in inches, the power gained by the machine will be as $\overline{a^2+a}\times 6.28326$ to 1. This form of the screw Mr. Hunter has proposed to apply to the single and double microscope, for the purposes of adjustment; to the micrometer, and to a jack for raising great weights through a small height.

SECT. VI. *On the Wedge.*

A wedge is a triangular prism ABCDEF, (Plate CCCLXII. Fig. 19.) which is introduced into a cleft or opening in any body, for the purpose of separating the two parts of which it consists. The part ABCD is called the *head* or *back* of the wedge, EF its *edge*, FH its *altitude*, and AEFB, CDFE, its *faces*. It is called an *isosceles*, a *rectangular*, or a *scalene* wedge, according as the triangle FBD is an isosceles, a rectangular, or a scalene triangle. The common purposes to which the wedge is applied are those of cleaving wood and cutting masses of stone out of a quarry; but all instruments, such as knives, swords, chissels, &c. may be regarded as wedges when they act at right angles to the cutting surface; but when they act obliquely to their edge, and are made to cut by a sort of drawing motion, in which case their power is greatly increased, the process of cutting resembles more the action of a saw. A pair of scissars is a compound machine, uniting the power of the lever with that of the wedge. The wedge is sometimes employed also for raising weights, and for compressing bodies.

The power which is commonly applied to the wedge is the blow of a hammer upon its head ABCD; and we have therefore to determine the force which will be exerted upon the two faces of the wedge, and in a direction perpendicular to them.

PROP. I.

If a force is exerted perpendicularly on the head of a wedge, it will be to the resistance which the parts of the body oppose to its action as the head of the wedge is to the sum of its sides.

Let a wedge ABC be introduced into a cleft of the body MN, for the purpose of separating its two parts M, N, and let the force be applied perpendicularly to the head in the direction DF, lying in the plane ABC. Then it is obvious, that as the force DF can only be destroyed or balanced by the resistance which the body opposes to the separation of its parts, it may be resolved into two forces directed to the point of resistance GH, and perpendicular to the forces AC, BC of the wedge, which we may consider as tangents to the points of resistance at G and H. The force DF, therefore, and the two resistances at G and H, are in the same plane, and meet in the point F. If we, therefore, call these three forces P, P′, P″, and consider that their directions FE, FG, FH, are respectively perpendicular to the three sides AB, AC, BC of the triangle ABC, we shall have (Cor. 7. Prop. I. Statics.) $P : W : W'=AB : AC : BC$, and consequently $P : P'+P''=AB : AC+BC$. But since the forces exerted at G and H are destroyed, in consequence of the equilibrium by the equal and opposite resistances which are to be opposed to them on these points, and which we call W′ W″, we have $P'=W'$, and $P''=W''$; and therefore $P : W'+W''=AB : AC+BC$: that is, the force exerted on the head of the wedge is to the sum of the resistances as the head of the wedge is to the sum of its two sides.

COR. 1. If the section of the wedge is an isosceles triangle; that is, if $BC=AC$, we shall have $P : W'+W''=AB : 2\,AC=\frac{AB}{2} : AC$; and therefore the force exerted perpendicularly on the head of the wedge is to the sum of the resistances which are opposed to its action as half the head of the wedge is to one of its sides.

COR. 2. As the power of the wedge increases as AC lengthens, and as AB diminishes, a very high degree of mechanical power may be exerted by the wedge by very small blows upon its head. In practice it is the custom to use at first very small wedges with small angles, and, when they are sunk in the body to be cleft, larger wedges with larger angles are successively applied till the purpose is accomplished.

SECT. VII. *On the Rope Machine.*

When a body is drawn or suspended by means of a single rope acting in the direction of its length, the rope does not perform the part of a machine, as the power which is applied to the body is neither increased nor diminished, nor in any way altered by the intervention of the rope; but if the rope is fixed at one end, and if a power is applied to an intermediate point of the rope, so as not to act in the direction of the rope, the body at the other end of the rope will be acted upon with a force different from that which is applied, and, therefore, the rope becomes in this way a mechanical power, in which state it is called the *rope* or *funicular machine*.

PROP. I.

If a weight suspended by a rope is held in equilibrium by means of two powers, acting at the ends of ropes all meeting at the same point, the three forces will be each to one another as the sines of the angles formed by the directions of the other two.

Let the weight W (Plate CCCLXIII. Fig. 1.) be in equilibrio with the two powers P, P', applied at the ends of the ropes PA, $P'A$, then it is obvious that the resultant of the two forces P, P' must be equal, and opposite to the weight W. But as these forces are all in the same plane, if we take AD to represent the weight W as the resultant of P and P', we shall have by Prop. I. Statics, $W : P : P' = AD : AB : AC$, or BD; that is, the three forces are to one another as the sides of the triangle ABD; but as the sides are to one another as the sines of the opposite angles, we have $W : P : P' = \sin. PAP' \ (= ABD) : \sin. P'AD \ (= BDA) : \sin PAD$.

Cor. However small the weight W is in proportion to the powers P, P' by which it is sustained, the ropes PA, $P'A$ must always form an angle at A, which will approach to 180°, as the weight becomes infinitely small.

Prop. II.

To find the position which a weight W, (Plate CCCLXIII. Fig. 2.) ought to take, when suspended by a running ring A to the rope PAP', the extremities of which are fixed at P and P'.

Through the point P draw PQ parallel to the horizon, and through P' the vertical line $EP'F$, meeting PA prolonged in F, and PQ in E. The running ring at A will obviously descend along with the weight W, till it has the same direction with respect to the two ropes PA, $P'A$; that is, till $PAD = P'AD$. But $PAD = PFP'$, and $P'AD = AP'F$; consequently the triangle $AP'F$ is isosceles, and $AF = AP'$. Now in the right angled triangle PEF, the side PF is known, since $PF = PA + AF = PA + AP$, or the length of the rope; and as P and P' are given in position, PE is likewise known; and therefore PFP' may be found by plain trigonometry. In order to determine the place of the node A, let a circle be described from the point P as a centre, and with the radius $PF = PA + AP'$, cutting $EP'F$ in F, and then making the angle $EP'Q = EFP$; and prolonging QP' till it meets PF in A, the point A will be the place of the node required.

Such of our readers as wish to investigate this subject farther, are referred to Bossut's *Traité de Mecanique*, p. 76; Poisson's *Traité de Mecanique*, tom. i. p. 185 and 477; and Bridge's *Treatise on Mechanics*, Sect. X.

Sect. VIII. *On the general Law of Equilibrium in simple and compound Machines.*

In all the combinations of the simple mechanical powers which we have just described, the condition of equilibrium may be easily computed, by tracing and calculating the effects of all its separate parts, the effect produced at one part being always considered as the power which is applied to the next part. The relation, however, between the power and the effect may be obtained by a very simple rule, deduced from the principle of virtual velocities; namely, that if the points of the machine, to which the power and the resistance are applied, be made to describe an infinitely small space, the power will be to the weight or resistance, as the space described by the point to which the weight or resistance is applied is to the space described by the point to which the power is applied; that is, if P is the power, W the weight, p the space described by the power, and w the space described by the weight, we shall have $P : W = w : p$; or, what is the same thing, the power is to the weight as the velocity of the weight is to the velocity of the power; and hence is deduced the well-known principle in mechanics, that, in all combinations of the mechanical powers, whatever is gained in power is lost in time.

It is unnecessary to prove the truth of this principle in all the mechanical powers. The single case of the lever will shew how easily it may be done in all the other simple machines.

Let ACB, (Plate CCCLXI. Fig. 4.) be a lever, and let us suppose the power and weight applied to the extremities a and b of the perpendiculars let fall from the fulcrum C upon the lines of direction aA, bB. When the lever is made to move round C, its extremities A, B will describe the circular arches mm, nn, of the same number of degrees, and to which the direction of the forces P, W are tangents. But $mm : nn = Cb : Ca$; and since $mm : nn = p : w$, we have $p : w = Cb : Ca$; and as this ratio remains the same, however small be the space described by the extremities a and b, we shall have

$$P : W = Cb : Ca.$$

CHAP. III.

ON THE MOTION OF BODIES ALONG INCLINED PLANES, THE OSCILLATIONS OF PENDULUMS, AND THE CURVE OF QUICKEST DESCENT.

Sect. I. *On the Motion of Bodies along inclined Planes.*

Prop. I.

When a body descends along an inclined plane, its relative gravity, or the force which accelerates its motion, is to the absolute force of gravity as the height of the inclined plane is to its length.

Let the body O, (Plate CCCLXIII. Fig. 3.) descend the inclined plane AB, whose vertical height is AC. Let the vertical line OP represent its absolute weight, then, as this force may be resolved into OM perpendicular to the plane, and ON parallel to it, it is obvious that the first is destroyed, and that it is only in virtue of the second that it descends. But the triangles ONP, ACB, are similar on account of the right angles at N and A; and from the equal angles PON, ACB, we have $ON : OP = AC : AB$; *that is, its relative is to its absolute gravity as the height of the inclined plane is to its length.*

Cor. 1. Since the preceding ratio is constant in whatever part of the inclined plane the body is placed, the relative gravity or force ON is a constant accelerating force, which produces equal degrees of velocity in equal times; and therefore the laws of accelerated and retarded motions given under Dynamics, are equally applicable to the motions of bodies upon inclined planes.

Prop. II.

If a body falls along the vertical diameter of a circle, and another descends at the same time an inclined plane, whose length and inclination are those of a chord of the circle drawn from the summit of the vertical diameter, the two bodies will reach the extremities of the diameter and the chord at the same time.

Since the relative is to the absolute force of gravity in a body descending in an inclined plane, as $AC : AB$, then if we draw a perpendicular ab from any point a, we shall have the relative to the absolute force of gravity, as $A a : A b$, on account of the similarity of the triangles $A a b$, ABC; that is, since the forces are measured by the spaces described in equal times, two bodies descending along $A a$ and $A b$ will arrive at a and b at the same instant. If we now describe a circle passing through the points A, a, b, its centre will be in the line AC, because $A a b$ is a semicircle on account of the right angle $A a b$, and $A b$ will be its vertical diameter, and $A a$ one of its chords. Hence the body descending from A will fall through the chord $A a$ in the same time that it will fall through the vertical diameter $A b$.

Cor. 1. Since the same is true of every other chord of the circle, it follows that the time of descending through any one chord is equal to the time of descending through any other chord.

Cor. 2. If the bodies descend a number of inclined planes, having their summit at A, and all lying in different planes, the bodies will at the end of a given time be found in the circumference of a sphere, whose diameter is equal to the space that a body would have described in that time by the force of gravity alone.

Prop. III.

If a body descends from a given point to a horizontal line, by a series of inclined planes, without losing any velocity at their points of junction, it will reach the horizontal line with a velocity equal to that which it would have acquired by falling vertically from the given point to the horizontal line.

Let the inclined planes be represented by AB, BC, CB, (Plate CCCLXIII. Fig. 4.) forming different angles with the horizon, and let $A a$ be a vertical line. Through the points B, C, and D, draw the horizontal lines $B b$, $C c$, and $D d$. Then since the body setting out from A will descend to B with the same velocity that it would acquire by falling vertically through $A b$, and since the same is true of the planes BC, and the vertical height $b c$, and of the plane CD, and the vertical height $c d$, it follows that it will arrive at D with the same velocity that it will acquire by falling through $A d$, since it enters upon each successive plane without any obstruction or loss of velocity.

Cor. As the proposition is true, whatever be the number of planes, it will be true also of any curve line whatever, which may be considered as composed of an infinite number of straight lines.

Prop. IV.

The times of descent down two planes equally inclined, but of different lengths, are as the square roots of the lengths, or of the heights of the planes.

Let T, t = times of descending the planes, L, l their lengths, H, h their vertical heights, and F, f the absolute accelerating forces. Then if we call g, γ, the absolute gravities of the two bodies, we shall have, by Prop. I. $F = \frac{gH}{L}$, $f = \frac{\gamma h}{l}$; but since by Dynamics, cor. 6. $F = \frac{2MS}{T^2}$, and $f = \frac{2ms}{t^2}$, we obtain $FT^2 = 2MS$, and $ft^2 = 2ms$, and $FT^2 ms = ft^2 MS$. Now in the present case we have $L = S$, and $l = s$, and therefore by substituting these letters, and the values of F, f, given above, we have $\frac{gHT^2 ml}{L} = \frac{\gamma h t^2 ML}{l}$, or $gHT^2 m l^2 = \gamma h t^2 ML^2$. But since the absolute gravities g, γ, are as the masses M, m, we have $g : \gamma = M : m$, and $gm = \gamma M$. Dividing, therefore, the preceding equation by these equal quantities, we have $HT^2 l^2 = h t^2 L^2$. Now since the planes are equally inclined. $L : l = H : h$, and $L h = l H$; hence, dividing again by these equal quantities, we get $T^2 l = t^2 L$, and consequently $T : t = \sqrt{L} : \sqrt{l} = \sqrt{H} : \sqrt{h}$; that is, the times are to one another as the square roots of the lengths, or the heights of the inclined planes.

Sect. II. *On the Oscillation of Pendulums in Circular Arcs.*

A *simple pendulum* is a small weight attached to a thread, or a slender inflexible rod; and it is said to swing, vibrate, or oscillate, when it has a motion backwards and forwards round one extremity of the thread or rod when fixed. The pendulum is said to be *compound* when it consists of an assemblage of weights and rods, which are made to oscillate round a point or a fixed axis.

If the body B, Fig. 5. having a motion round A as a centre, is raised to the position B, and being allowed to fall by its gravity, rises to the point b, where it again descends, the arch $B b$ is called the *arc of vibration;* and the time in which the body B describes this arc, is called the *the time of an oscillation.* When the oscillations of pendulums are performed in equal times, they are said to be *isochronous.*

Prop. I.

If a pendulum AB, (Plate CCCLXIII. Fig. 5.) acted upon solely by the force of gravity, is allowed to oscillate by descending from B, it will ascend to b; so that $BC = C b$, and the arches BC, $C b$ will be described in equal times.

As the body B has acquired a certain velocity at the point C, it will necessarily ascend on the other side of C, but as the force of gravity continues to act in the same manner during its ascent to b as during its descent to C, the body must experience the same retardation in its ascent, as it was accelerated in its descent. Hence the body will rise through a height $C b = CB$; and as the velocities at equal distances from C must be the same in the ascent as in the descent, the whole time of ascending from C to b must be equal to the whole time of descending from B to C.

Lemma.

If the moving forces of two bodies are proportional to the products of the masses by the spaces described, the spaces will be described in equal times. For since the moving forces are equal to the product of the velocities by the masses, and as the velocities are as the spaces when the times are equal, it follows, that when the moving forces are as the product of the masses by the spaces described, the times must be equal.

Prop. II.

The oscillations of a single pendulum describing very small circular arcs, are isochronous.

If AB, (Fig. 5.) is a pendulum oscillating round A, then if the ball a is lifted up to B, so as to describe the very small arc B b, and is afterwards lifted up to B′ so as to describe the arc B′ β, it will describe the arcs B b and B′ β in the same times. Let the gravity of the pendulum be represented by BN, B′N′, then constructing the parallelogram of forces, we shall find that the forces BN, BN, are resolvable into BM, BO, B′M′, B′O′, of which the forces BO, B′O′, are destroyed by the resistance of the thread AB, while the other two, BM, B′M′, tangents to the arc of vibration at B and B′, are the only ones which give motion to the ball B. But as the arches BC, B′C, are by hypothesis very small, we may consider the sectors ABC, AB′C, as triangles, which are similar to BNM. B′N′M′. Hence we have $\mathrm{BM}:\mathrm{BN}=\mathrm{BC}:\mathrm{AC}$, and $\mathrm{B'M'}:\mathrm{B'N'}=\mathrm{B'C}:\mathrm{AC}$, and $\mathrm{BM}=\mathrm{BN}\times\frac{\mathrm{BC}}{\mathrm{AC}}$, $\mathrm{B'\,M'}=\mathrm{B'N'}\times\frac{\mathrm{B'A}}{\mathrm{AC}}$; consequently $\mathrm{BM}:\mathrm{B'M'}=\mathrm{BN}\times\mathrm{BC}:\mathrm{B'N'}\times\mathrm{B'C}$; but as $\mathrm{BN}=\mathrm{B'N'}$ we have $\mathrm{BM}:\mathrm{B'M'}=\mathrm{BC}:\mathrm{B'C}$. Let us now conceive the arches BC, B′C to be divided into an infinite number of corresponding elementary portions, then since the forces such as BM, BM, by which the body B describes each of these small elementary portions, are proportional to the elementary portions themselves, or to the spaces described, it follows from the **Lemma**, that the elementary portions are described in equal times, and therefore the arcs BC, B′C, and the whole arcs of vibration B b, Bβ, are described in equal times.

Prop. III.

If two pendulums have different lengths, the times of their oscillation will be in the subduplicate ratio of their lengths.

Let BC, DF, (Plate CCCLXIII. Fig. 5 and 6,) be two very small and similar semi-arcs, described by the pendulums AB and ED, and let F and f be the tangential forces by which they are moved, and B, D their weights. We have by Prop. I. $\mathrm{F}:f=\mathrm{B}\times\frac{\mathrm{BC}}{\mathrm{CA}}:\mathrm{D}\times\frac{\mathrm{DF}}{\mathrm{FE}}$. But since the arcs BC, DF, are by hypothesis similar, $\frac{\mathrm{BC}}{\mathrm{CA}}=\frac{\mathrm{DF}}{\mathrm{FE}}$, and hence $\mathrm{F}:f=\mathrm{B}:\mathrm{D}$, that is, as the weight of the two bodies. If we now suppose the arcs BC, DF, divided into an infinite number of corresponding elementary portions, we may consider any two of these as two similar inclined planes; and since the string which supports the bodies B and D performs the same part as an inclined plane, the forces will in both cases be the same. The times therefore in which these elementary planes will be described will, by Prop. iv, p. 612, be as the square roots of their lengths, and consequently as the square roots of AC and EF, since the lengths of similar arcs are as the radii. Hence it follows, that the times in which the pendulums AB, ED, describe the whole arcs B b and D d, will be in the subduplicate ratio of their lengths.

Cor. If the time in which a pendulum of a given length performs an oscillation, is known from experiment, the time in which another pendulum of a different length will perform an oscillation, may be found by proportion. A pendulum, for example, 39 14 inches, vibrates seconds in the latitude of London, according to Captain Kater's experiments; then if we wish to know the length of a pendulum that would vibrate minutes, we have

$1'':60''\sqrt{39.14}$ inches : $\sqrt{140905}$ inches, or 11742 feet.

Sect. III. *On the Oscillation of Pendulums in Cycloidal Arcs.*

As the oscillations of pendulums vibrating in circular arcs are isochronous, only when the arcs are very small, Huygens, the celebrated inventor of the pendulum, set himself to discover some method by which the long and short vibrations of pendulums could be rendered perfectly isochronous. In this investigation he discovered, that if a pendulum could be made to vibrate in a cycloidal arc, all its vibrations would be performed in equal times; and he contrived the method explained in our article **Horology**, and represented in Plate CCC. Fig. 4. and Fig. A. for carrying this fine idea into effect. As no practical advantage, however, was found to result from this contrivance, it has never been employed in the construction of pendulums, but the theory of the vibration of pendulums in the arc of a cycloid has retained its place in every treatise on mechanics. The properties of the cycloid, upon which this theory is founded, will be found in our article **Epicycloid**.

Prop. I.

If a body P vibrates in a cycloidal arc ADB, its velocity will vary as the sine of a circular arc, whose versed sine is equal to the space described from the beginning of its motion, and whose radius is equal to half the length of the cycloidal arc.

Let VP (Plate CCCLXIII. Fig. 7.) be a pendulum vibrating between two cycloidal cheeks VA, VB, as described in **Horology**, *Loc. Cit.* and let ADB be the cycloid in which it vibrates, as demonstrated in the article **Epicycloid**, Prop. IX. Join AB, and having drawn VD a vertical line, describe upon CD the semicircle CTWD. Let the body P begin to descend from P, and let Q be any other point of its path. From P, Q draw PR, QS perpendicular to VD, and meeting the semicircle CTWD in the points T and W. Join TD, WD, then through the point D draw D p, at right angles to DV, and with the radius $\mathrm{D}p=\mathrm{DP}$ describe the semicircle $p\mathrm{E}\pi$. Make $pq=\mathrm{PQ}$, and having drawn $q\,x$ parallel to DV, join Dx. Considering PQ as an inclined plane described by the body P. the velocity of P is proportional to its altitude $\sqrt{\mathrm{Q}r}=\sqrt{\mathrm{RS}}$; but since $\mathrm{RS}=\mathrm{DR}-\mathrm{DS}$, and since CD is constant, the velocity of P will vary as $\sqrt{\mathrm{CD}\times\mathrm{DR}-\mathrm{CD}\times\mathrm{DS}}$. Now, $\mathrm{DT}^2=\mathrm{CD}\times\mathrm{DR}$, (**Geometry**, Prop ix. and xi. and Prop. xxviii.) and for the same reason, $\mathrm{DW}^2=\mathrm{CD}\times\mathrm{DS}$: hence the velocity of P will vary as $\sqrt{\mathrm{DT}^2-\mathrm{DW}^2}$. But (Article **Epicycloid**, Prop. vi.) $\mathrm{DP}=2\ \mathrm{DT}$ and $\mathrm{DQ}=2\ \mathrm{DW}$. consequently the velocity of P will vary as $\sqrt{\mathrm{DP}^2-\mathrm{DQ}^2}$. Again, since $\mathrm{D}q=\mathrm{DQ}$, and $\mathrm{D}p=\mathrm{DP}$, we have $qx^2=\mathrm{D}x^2-\mathrm{D}q^2=\mathrm{D}p^2-\mathrm{D}q^2=\mathrm{DP}^2-\mathrm{DQ}^2$, consequently the velocity of P will vary as $\sqrt{q\,x^2}$, or as qx, which is obviously the sine of a circular arch $p\,x$, whose versed sine, $p\,q$, is equal to PQ, the space described from the beginning of the motion, and whose radius Dp is half the length of the cycloidal arc PP′.

Cor. Since the sine of the circular arc is equal to radius, when the point q coincides with D, the velocity at Q will be to the velocity at D as Dx : qx.

Prop. II.

The time in which the pendulum describes the cycloidal arc PP, is equal to the time in which a body would describe the corresponding semicircle pEπ, with the velocity which it acquires at the point D continued uniformly.

Let QH be an indefinitely small arc of the cycloid; make qh=QH, and draw hz and xy parallel to qx and Dp respectively. Now, since QH is very small, we may conceive it to be described with the velocity at Q continued uniform, and consequently the time of describing QH will be represented by $\frac{qh}{qx}$, for qh = QH. But the velocity of D is (by Cor. Prop. II.) represented by Dx, and therefore if a body were to describe the semicircle pEπ, with the velocity Dx continued uniform, the time of describing the small arch xz will be represented by $\frac{xz}{\mathrm{D}x}$. Now, in the similar triangles Dxq, xyz, $\mathrm{D}x : qx = xz : xy$ or qh; consequently $\frac{qh}{qx} = \frac{xz}{\mathrm{D}x}$; that is, the time of describing the cycloidal arc QH is equal to the time of describing the corresponding circular arc xz, with the velocity at D uniformly continued; and as the same may be demonstrated of all the other corresponding arcs of the cycloid and the semicircle, it follows that the time in which the pendulum VP describes the whole cycloidal arc PDP′, is equal to the time in which a body would describe the whole of the corresponding semicircle pEπ, with the velocity which the pendulum acquires at the lowest point D of its path.

Prop. III.

The time in which a pendulum describes a cycloidal arc, is to the time in which a heavy body would fall freely by the force of gravity, along the axis of the cycloid, as the circumference is to the diameter of a circle.

The velocity of the pendulum at the lowest point D, is equal to the velocity which a body would acquire by falling down TD, or through the vertical height CD. But if the velocity acquired by falling down TB were continued uniform, the body would describe in the same time a space equal to 2 TD=DP =Dp. Hence, since the time of an oscillation is by Prop. II. equal to the time of describing the semicircle pEπ, with the velocity at D, and since the time of describing CD is equal to the time of describing DP=Dp, with the same velocity, it follows that the time in which the pendulum describes the cycloidal arc PDP, is to the time of descent down CD the axis, as the time of describing the semicircle pEπ, with the velocity at D, is to the time of describing DP=Dp, with the same velocity; that is, as a semicircle is to its radius, or as the circumference of a circle is to its diameter.

Cor. 1. The vibrations of a pendulum describing cycloidal arches of different lengths, are isochronous, or performed in equal times; for as the time of an oscillation is to the time of descent along the axis, in a constant ratio, whatever be the point from which the oscillations begin, the time of performing oscillations of different lengths must be equal.

Cor. 2. The time in which a pendulum describes a small circular arc whose radius is VC, is to the time of descent down CD, or half the length of the string, as the circumference of a circle is to its diameter.

For since VC=CD, and since a small cycloidal arch at D may be considered as a circular arch whose radius is VD, (Epicycloid,) the time of oscillation in the circular arch will be the same as that in the cycloidal arch; that is, it will be to the time of descent along the axis, as the circumference of a circle is to its diameter.

Prop. IV.

To determine the space through which heavy bodies fall, in a second of time, by the force of gravity.

Captain Kater, in his late ingenious and accurate experiments, found that the length of a pendulum vibrating seconds, at London, at the level of the sea, and in a temperature of 62°, was 39.1386. But since, by Prop. iii. Cor. 2, the time of an oscillation, or 1″, is to the time of falling through one half of the length of the pendulum, as the circumference of a circle is to its diameter; and since the spaces are as the squares of the times, the space which a heavy body will fall through in the time of an oscillation, will be to half the length of the pendulum as the square of the circumference of a circle is to the square of its diameter; that is, as

$1^2 : \overline{3.14159}^2 = \frac{39.1386}{2}$, or 19.5693 : 193.141 inches, or 19.095 feet.

Sect. IV. *On the Curve of Swiftest descent.*

In the Leipsic Acts for 1696, John Bernoulli proposed to geometers the famous problem of the *Curve of swiftest descent.* To this problem he gave the name of *brachystroe*, a Greek word, which signifies the shortest time. The object of the problem was, "to determine the curve line connecting two given points which are at different distances from the horizon, and not in the same vertical line, along which a body passing by its own gravity, and beginning to move at the upper point, shall descend to the lower point in the shortest time possible.

John Bernoulli prescribed six months as the period in which the solutions were to be given in; but at the request of Leibnitz, who was then occupied with other matter, the period was extended to twelve months. Three solutions only were given, namely, one by Newton, another by James Bernoulli, and a third by the Marquis de l'Hospital. The following solution, the steps of which we have attempted to simplify, is given by Dr. Thomas Young, in his Lectures on Natural Philosophy, vol. 2.

Prop. I.

An inverted semi-cycloid is the curve of quickest descent, or the curve along which a body must descend in order to move between two points not in a vertical line, in the shortest time possible.

Let q FZ (Plate CCCLXIII. Fig. 8.) be a semicycloid, and A′D′, C′F′, two parallel and vertical ordinates at an infinitely small distance. Draw the ordinate B′E′ an arithmetical mean between the ordinates A′D′ and C′F′, and from F′E′, draw F′v, E′u perpendicular to B′F′, C′E′. Make C′F′$=a$, B′E′$=b$, E′$v=c$, C′B′$=$m, B′A′$=n$. Then since F′E′ may be considered as a straight line, and since B′C′$=$F′v, we have (*Euclid.* B. I. Prop 47.) F′E′$=\sqrt{m^2+c^2}$; and since F′$v=$E′u, E′D′ $=\sqrt{n^2+c^2}$. Now the velocities at F′ and E′ vary as $\sqrt{a}$ and $\sqrt{b}$, and F′E′, E′D′ are the elementary spaces described with these velocities; but the times are directly as the square roots of the spaces, and inversely as the velocities; therefore the time of describing F′E′ is $\frac{\sqrt{m^2+c^2}}{\sqrt{a}}$, and the time of describing E′D′ is $\frac{\sqrt{n^2+c^2}}{\sqrt{b}}$; consequently, the time of describing FD must be $\frac{\sqrt{m^2+c^2}}{\sqrt{a}}+\frac{\sqrt{n^2+c^2}}{\sqrt{b}}$. But the proposition requires that this time should be the shortest possible, or a minimum; therefore taking its fluxion and making it equal to 0, we have

$$\frac{2\,m\,\dot{m}}{2\sqrt{a\times\overline{mm+c^2}}}+\frac{2\,n\,\dot{n}}{2\sqrt{b\times\overline{nn+c^2}}}=0$$

But since CA is invariable, $m+n$ is invariable, and therefore its fluxion $\dot{m}+\dot{n}=0$, or $\dot{m}=-\dot{n}$ and $\dot{n}=-\dot{m}$; consequently, by transposing the second member of the preceding equation, and substituting these values of $\dot{m}$ and $\dot{n}$, it becomes $\frac{m}{\sqrt{a\times\overline{m^2+c^2}}}=\frac{n}{\sqrt{b\times\overline{n^2+c^2}}}$. Let us now call the variable absciss q C′$=x$, the ordinate C′F′$=y$, and the arc q F′$=z$, then m and n are fluxions of x, and F′E′ is the increment of q F or z, when y is equal to a, and E′D′ the increment of q F or z, when y is equal to b; therefore by substituting these values in the preceding equation, we obtain $\frac{x'}{\sqrt{yz'}}=\frac{x'}{\sqrt{yz'}}$, which shews that this quantity is constant, and gives us the following analogy, $z':x'=1:\sqrt{y}$. Now in the cycloid $\surd, y$ is always the chord of the generating circle when the diameter is y (for by Geometry Prop. ix. and xi. and Prop. xxviii.) AF$=\sqrt{\text{AD}\times\text{AO}}$, and since AO$=1$ and AD$=y$, we have AF $=\sqrt{y}$. But since the arc of the cycloid at F (Plate CCCLXIII Fig. 9.) is perpendicular to the chord AF, the elementary triangle FE v is similar to FDO, (for BE is parallel to AO) and consequently to AFO (Geometry, Prop. xxi.) therefore we have FE : E′ z'=AO : AF; but FE$=x'$, E v, AO$=1$ and AF$=\sqrt{y}$, consequently $z':x'=1:\sqrt{y}$, which coincides with the analogy already obtained, and being the property of the cycloid, shews that the curve of quickest descent is an inverted cycloidal arc.

The following is the construction given by Sir Isaac Newton, in the *Phil. Trans.* 1696-7, No. 224, p. 384.

From the one given point A (Plate CCCLXIII. Fig 10.) let there be drawn an indefinite right line APCZ parallel to the horizon, and on the same right line let there be described any cycloid AQB, meeting in Q, with the right line AB drawn and produced, if necessary, through the other given point B; as also another cycloid ABC, whose base and altitude may be to the base and altitude of the former respectively, as AB to AQ. Then this last cycloid will pass through the point B, and will be that curve line in which a body falling by the force of gravity will pass soonest from the point A to the point B.

M. Venturi has shewn that there is a minimum in the time of descent, even in circular arcs; that an arc of a circle which does not exceed 60°, is a curve of quicker descent than any other curve which can be drawn within the same arc; and that an arc of 90° is an arc of quicker descent than any other curve which can be drawn without the same arc.

Prop II.

If AVB (Plate CCCLXIII. Fig. 10.) be the curve of swiftest descent from A to D, then if from A there be any line drawn, the right line AB meeting the cycloid in B, and if BC be drawn perpendicular to the cycloid at B, and the perpendicular AC let fall upon this line from the point A, the time in which a body at rest, falling from A by the force of gravity, describes the right line AB, is to the time in which it moves along the curve AVD, as AB is to AC.

Through B draw BL, parallel to the axis VE of the cycloid, and BK parallel to the base AD, meeting the axis in G, and a circle described on the diameter EV in F and H, and, lastly, meeting the cycloid in K. Draw the right line EF, which will be parallel to the right line BC. Whence BM$=$EF, and EM$=$BF$=$VF; and therefore, AM$=$EHVF. But, by Prop. III. Cor. 2. p. 614, the time of passing over AV, is to the time of falling through EV as the semicircumference is to the diameter of a circle, and the time in which a body describes VB, after having passed over AB, is to the time of describing AV, as the arc VF is to the semicircumferences, and, therefore, to the time of the fall through EV, as the arc FV is to the diameter. Therefore, the time in which a body describes the curve AVB, is to the time of falling through EV, as the arc EHVF is to the diameter EV; but the time of the fall through EV, is to the time of the fall through LB, or EG, as EV is to EF. Therefore, *ex æquo*, the time of a body's describing AVB, is to the time of the fall through LB as the arc EHVF is to the subteuse EF; that is, as the right line AM is to the right line MB. Again, the time of the fall through LB, is to the time of describing AB, as LB is to AB; therefore the ratio of the time in which the body passes along AVB to the time of describing AB, is in the compound ratio of AM to MB, and LB to BA, and is therefore equal to the ratio of AM×LB, to MB×BA. But AM × LB $=$ MB × AC, because each of them is equal to twice the triangle ABM; and, therefore, the time in which a falling body from rest describes the curve of the cycloid AVB, is to the time in which it passes along the line AB, as MB×AC is to MB×BA; that is, as AC is to AB.

The preceding demonstration was given anonymously in the *Philosophical Transactions* for 1696 7, No. 225. p. 429, but it has always been regarded as the production of Sir Isaac Newton.

For farther information on the subject of this section, see *Act. Lips.* 1697; *Commerc. Phil. Leibnitz ac Bernouilli*, tom. i. p. 244; Newton, *Phil. Trans.* No. 224. p. 389. 424; Sault, *Phil. Trans.* 1698, No. 246. p. 425; Craig, *Phil. Trans.* 1701, vol. xxii. p. 746; Saurin, *Mem. Acad. Par.* 1709, p. 257; 1710, p. 203; Machin, *Phil. Trans.* 1718, vol. xxx. p. 86; Bernoulli, *Mem. Acad Par.* 1718, p. 136; Dr. Thomas Young's *Lectures on Nat. Phil.* vol. ii. p. 34; Poisson's *Traité de Mecanique*, vol. i. p. 425, &c.

CHAP. III.

ON THE COLLISION OR IMPACT OF BODIES.

When a body in motion strikes another body, either in motion or at rest, the first body is said to impinge against the second; and this class of facts has been distinguished by the name of collision, impact, or percussion.

Definition 1.—The collision of two bodies is said to be *direct*, when the two bodies move in the same straight line, and when this line joins their centres of gravity.

Definition 2.—A body is said to be *perfectly hard*, when its particles will not change their relative position when it is struck by other bodies; and it is said to be *imperfectly hard*, when its particles suffer a change in their relative positions.

Definition. 3.—A body is said to be *perfectly elastic*, when its particles experience a change in their relative positions when it is struck by another body, and when, after they have suffered this change, they restore themselves exactly to their primitive positions. The force from which they receive a change in their positions has been called the *force of compression*, and the force by which they recover their primitive positions has been called the *force of restitution.*[*] In perfectly elastic bodies, therefore, these two forces are equal; and in imperfectly elastic bodies the force of restitution is inferior to the force of compression, and, therefore, the particles of the body do not recover their primitive position.

Definition 4.—A body is said to be *perfectly soft*, when its particles have no force of restitution; and, consequently, bodies of this kind never recover their shape when it has been changed by compressing forces.

The characters of *perfect hardness*, *perfect elasticity*, and *perfect softness*, do not exist in nature. All bodies with which we are acquainted, even clay itself, possess a certain degree of elasticity.

Prop. I.

If two perfectly hard bodies A, B, impinge against one another directly, they will either be at rest after impact, or will move on together as if they were one mass.

If the momentum of A is equal to that of B, and if the bodies move in opposite directions, then the two bodies will obviously rest after impact. If the momentum of A exceeds that of B, the momentum of B will be destroyed; and as the momentum of A will not be destroyed, it will communicate velocity to B, which will thus be carried backward, retarding A by its re-action, till they move on uniformly.

If the bodies move in the same direction, let A have a greater velocity than B, then A will overtake B, and will continue to accelerate the motion of B; but as B also retards A's motion, their velocities will become equal, and as there is no cause by which they can be separated, they will both move on together with a uniform motion.

Prop. II.

If two perfectly hard bodies impinge directly against one another, the common velocity with which they move after impact, is equal to the whole momentum before impact, divided by the sum of their quantities of matter.

Let A and B be the quantity of matter in the two bodies, and a and b their respective velocities, and consequently Aa, Bb, their momenta before impact. If the bodies move in the same direction, the sum of their momenta before impact will be $Aa+Bb$; but when they move in opposite directions, the sum of their momenta, estimated in the direction of A's motion, will be $Aa-Bb$. Let v represent their common velocity after impact, then the momenta of both bodies moving in one mass will be $\overline{A+B}\times v$; but since, by the third law of motion, action and reaction are equal and opposite, it follows, that whatever momentum is lost by one body is gained by the other, and, therefore, that no momentum is lost by collision. Hence we have $A+B\times v=Aa\pm Bb$, and $v=\frac{Aa\pm Bb}{A+B}$; the positive signs being used when the bodies move in the same direction, and the negative signs when they move in opposite directions.

Prop. III.

To determine the velocity lost by the one body, and the velocity gained by the other, when two perfectly hard bodies impinge against each other.

1. *When the bodies move in the same direction.*—Estimating the effects in the direction of the motion of A, the velocity lost by A must be equal to the difference of its velocities before and after impact; that is,

$$\text{Velocity lost by A}=a-\frac{Aa+Bb}{A+B}=\frac{Ba-Bb}{A+B}.$$

In like manner, the velocity gained by B must be equal to the difference between its velocity after impact, and its velocity before it; that is,

$$\text{Velocity gained by B}=\frac{Aa-Bb}{A+B}-b=\frac{Aa-Ab}{A+B}.$$

2. *When the bodies move in opposite directions.*—The velocity lost by A being equal as before to the difference of its velocities before and after impact, we have

$$\text{Velocity lost by A}=a-\frac{Aa-Bb}{A+B}=\frac{Ba+Bb}{A+B}.$$

In like manner, the velocity gained by B will be equal to the difference of its velocities before and after impact; but as these two velocities are in opposite directions, the sign of B's velocity before impact must be changed, and will become $-b$; but the difference between $+v-b$ is $b+v$: hence

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[*] In glass, the force of restitution is said to be to the force of compression as 15 to 16, and in steel as 5 to 9. Hence glass approaches very near to perfect elasticity.

Velocity gained by $B=b+\frac{Aa-Bb}{A+B}=\frac{Aa+Ab}{A+B}$.

The preceding values of the velocities lost and gained, give us the analogies,

$$\left.\begin{array}{l} A+B : A=a-b : \text{Vel. gained by B.}\\ A+B : B=a-b : \text{Vel. lost by A.}\end{array}\right\}\text{Bodies moving in the same direction.}$$

$$\left.\begin{array}{l} A+B : A=a+b : \text{Vel. gained by B.}\\ A+B : B=a+b : \text{Vel. lost by A.}\end{array}\right\}\text{Bodies moving in opposite directions.}$$

Now, since $a-b$ and $a+b$ are the relative velocities, it follows,

1. *That the sum of the momentā of the two bodies is to the momentum of the first as the relative velocity is to the velocity gained by the second; and*

2. *That the sum of the momenta of the two bodies is to the momentum of the second as the relative velocity is to the velocity lost by the first.*

Cor. 1. Making $r=a\pm b$, or the relative velocity, we have the velocity lost by $A=\frac{Br}{A+B}$, and the velocity gained by $B=\frac{Ar}{A+B}$; consequently the velocity lost by A, and gained by B, must remain the same, whatever be the value of their velocities a and b, provided the relative velocity r continues unchanged.

Cor. 2. When $A=B$, then the common velocity $v=\frac{Aa\pm Bb}{A+B}=\frac{a\pm b}{2}=\frac{r}{2}$; the velocity lost by $A=\frac{Br}{A+B}=\frac{r}{2}$, and the velocity gained by $B=\frac{Ar}{A+b}=\frac{r}{2}$, that is, when the bodies are equal, all the velocities are equal to half the relative velocity.

Cor. 3. If B is at rest before impact, then $v=\frac{Aa}{A+B}$; vel. lost by $A=\frac{Ba}{A+B}$, vel. gained by $B=\frac{A}{A+B}$; that is, the velocity gained by B is equal to the common velocity. If B is at rest, and $A=B$, then all the velocities are equal to $\frac{1}{2}a$.

Cor. 4. If the velocities of the bodies before impact are inversely proportional to the quantities of matter, they will both be at rest after collision. Hence by the hypothesis $A : B=b : a$, we have $Aa=Bb$; hence $v=\frac{Aa-Bb}{A+b}=0$; that is, the common velocity is nothing.

Cor. 5 The velocities lost by A and gained by B, are the same, whether the bodies are both in motion before impact, or A strikes B at rest with a velocity equal to their relative velocity. In both these cases, the velocity lost by A is $\frac{Ba}{A+B}$, and $\frac{Br}{A+B}$; consequently when $r=a$, these two expressions are equal. In like manner, the velocity gained by B in both these cases is $\frac{Aa}{A+B}$ and $\frac{Ar}{A+b}$, which are equal when $a=r$.

Prop. IV.

When two perfectly elastic bodies impinge against each other, the velocity gained by the one and lost by the other will be twice as great as when the bodies are perfectly hard.

When the two perfectly elastic bodies A and B come into contact, the same effect will be produced, and the same velocity lost and gained as in hard bodies, during the short period in which the compression is taking place. The bodies are therefore moving on uniformly with a common momentum before the force of restitution begins to exert itself. Consequently when the bodies begin to recover their figure, like two springs pressing against one another, the one will be driven off by a force equal to that with which the other tends to recover its shape; that is, with a force equal to the force of restitution, which is again equal to the force of compression.

When the bodies, therefore, impinge against each other, the body B, whose effort to recover its shape has a tendency to impel it in the direction of the common mass, will move on in that direction, having gained a velocity equal to the velocity gained, increased by the new velocity which it receives from the force of restitution; that is, the velocity gained by B after the force of restitution is exerted, is equal to twice the velocity gained before that force was exerted, and will therefore be represented by $\frac{2Aa-2Ab}{A+B}$.

In like manner, the body A, whose effort to recover its shape has a tendency to impel it in an opposite direction, will lose as much velocity by the force of restitution as it lost by the force of compression, and will therefore be equal to $\frac{2Ba-2Bb}{A+B.}$.

Cor. 1. Since the velocity of A after impact is equal to the difference between the velocity before impact and the velocity which it has lost, we have,

1. *When the bodies move in the same direction before impact.*

Velocity of A after impact $=a-\frac{2Ba-2Bb}{A+B}=\frac{\overline{A-B}\times a+2Bb}{A+B}$; and since the velocity of B after impact is equal to the sum of its velocity before impact, and the velocity which it has gained, we have,

Velocity of B after impact $=b+\frac{2Aa-2Ab}{A+B}=\frac{\overline{B-A}\times b+2Aa}{A+B}$.

2. *When the bodies move in opposite directions,* the sign of b is negative, and the

Vel. of A after impact $=\frac{\overline{A-\quad}\times a-2Bb}{A+b}$, and

Vel. of B after impact $=\frac{A-B\times b+2Aa}{A+B}$.

Cor. 2. When $A=B$, the bodies will, after impact, move with interchanged velocities. For, in this case, $A+B=2A=2B$, and $A-B=B-A=0$. Then the preceding formulæ become,

1. *When the bodies move in the same direction before impact.*

Vel. of A after impact $=\frac{2Bb}{A+B}=\frac{-2Bb}{2B}=b$.

Vel. of B after impact $=\frac{2Aa}{A+B}=\frac{2Aa}{2A}=a$.

2. *When the bodies move in opposite directions before impact.*

Vel. of A after impact $= \frac{-2Bb}{A+B} = \frac{2Bb}{2b} = -b.$

Vel. of B after impact $= \frac{2Aa}{A+B} = \frac{2Aa}{2A} = a.$

Cor. 3. If one of the bodies B is at rest, then since $b=0$, we have,

Vel. of A after impact $= \frac{Aa-Bb}{A+B}.$

Vel. of B after impact $= \frac{2Aa}{A+B}.$

If $A>B$, the velocity of A is positive, and A moves on after impact, and B's velocity is greater than a

If $A<B$, the velocity of A is negative. It is reflected back after impact, and B moves on with a velocity less than a.

If $A=B$, the velocity of $a=0$, and velocity of $B=a$.

Cor 4. If the velocities of the two bodies are equal, that is, $a=b$, then, in order to impinge upon one another, they must move in opposite directions; and we shall have,

$$\text{Velocity of A after impact} = \frac{\overline{A-B}\times a-2Bb}{A+B} = \frac{\overline{A-3B}\times a}{A+B}.$$

$$\text{Velocity of B after impact} = \frac{\overline{A-B}\times b+2Aa}{A+B} = \frac{\overline{3A-B}\times a}{A+B}.$$

Consequently if $A<3B$, the above values will be positive.

If $A=3B$, the vel. of A after impact $=0$, and vel. of $B=2a$.

If $A<3B$, the velocity of A will be negative, and that of B positive.

If $A<3B$, and $A>B$, the vel of A is negative, and that of B positive.

Hence it follows, that when $a=b$, if one of the bodies is more than triple the other, both of them will move on after impact in the direction of the greater body. If one of them is exactly triple the other, the greater body will remain at rest after impact, and the lesser body will be driven back with twice the common velocity before impact. If one of the bodies is greater than the other, but less than triple, both bodies will be reflected back again.

Cor. 5. If when $a=b$, we have also $A=B$; then

Vel. of A after impact $= \frac{\overline{A-3B}\times a}{A+B} = -a.$

Vel. of B after impact $= \frac{\overline{3A-B}\times a}{A+B} = a.$

That is, the bodies will move after impact with interchanged velocities.

Cor. 6. If the velocities of the bodies are inversely proportional to their quantities of matter, and if they move in opposite directions, the velocities with which the bodies recede from one another after impact, will be the same as those with which they approached each other before it. For since by Cor. 4. Prop. iii. p. 617, the bodies will be brought to rest after collision, in virtue of the force of compression alone, and since the force of restitution creates in opposite directions the same quantity of motion that was lost by compression, the bodies will recover the velocities which they had lost, and will consequently recede with these velocities.

Cor. 7. The relative velocities of two elastic bodies will be the same both before and after their impact. Make $\alpha=$ velocity of A after impact, and $\beta=$ velocity of B after impact, we have

$$\alpha = \frac{\overline{A-B}\times a+2Bb}{A+B}, \text{ and}$$

$$\beta = \frac{\overline{B-A}\times b+2Aa}{A+B}; \text{ consequently}$$

$$\alpha-\beta = a \mp b - \frac{\overline{2A+2B}\times a-b}{A+B};$$

and calling $r=$ relative velocity before impact, we have

$$\alpha-\beta = a \mp b - 2r.$$

the *negative* sign being used when the bodies move in the same direction, and the *positive* one when they move in opposite directions Hence, since when the bodies move in the same direction $r=a-b$, we obtain

$$\alpha-\beta = a-b-2a+2b = b-a = -\overline{a-b};$$

and since when they move in opposite directions $r=a+b$, we obtain

$$\alpha-\beta = a+b-2a-2b = -a-b = -\overline{a+b}.$$

Cor. 8. The *vis viva*, or the sum of the products obtained by multiplying each body into the square of its velocity, is the same both before and after impact. This is called the conservation of active forces. Since, by the third law of motion, the whole momentum is the same after impact as before it, we have $Aa+Bb = A\alpha+B\beta$ or $Aa-A\alpha = Ab-A\beta$, or $A\times\overline{a-\alpha} = B\times\overline{b-\beta}$. But by Cor. 7. $\alpha-\beta = b-a$, or $a+\alpha = \beta+b$; consequently we have, by multiplication, $A\times\overline{a^2-\alpha^2} = B\times\overline{\beta^2-b^2}$; and, by transposition, $Aa^2+Bb^2 = A\alpha^2+B\beta^2$.

Prop. V.

To determine the effects of the communication of motion along a row of elastic bodies.

1. *When the bodies are all equal.* Let A, B, C, D, &c. be the equal elastic bodies; then, if A is drawn back and made to strike B, and if this motion is communicated from B to C, D, &c. they will all remain at rest after impact, except the last, which will move forward with the velocity of A. Since $A=B$, then by Prop IV. Cor. 2. A and B will interchange velocities, that is, A will remain at rest, and B will have a tendency to move forward with the velocity of A. For the same reason, B and C will interchange velocities, B will remain at rest, and C will have a tendency to move on with B's velocity, and so on with all the rest except the last, which will move on with the velocity of the ball which strikes it, and consequently with A's velocity.

2 *When the bodies decrease in magnitude.* Since $A>B$, then, by Cor. 3. Prop. IV. both bodies will move forward, but B with a greater velocity than A. In like manner, since $B>C$, both B and C will move on, but C with a greater velocity than B, and so on with all the

rest, the last body moving forward with a velocity less than that of the one before, and greatly less than that of A. The bodies will therefore all separate, in consequence of every ball, reckoning from the foremost, moving off with a greater velocity than the one which precedes it.

3 *When the bodies increase in magnitude.* Since $A \angle B$, then, by Cor. 3. Prop. IV. the velocity communicated to B will be less than that of A, and A, whose velocity is now negative, will be reflected or driven back by B. In like manner, since $B \angle C$, the velocity communicated to C will be less than that of B, and B, whose velocity is now negative, will be driven back by C. Hence it follows, that all the bodies will be reflected backwards, excepting the last, which will move forward in the same direction as A originally moved before impact, but with a velocity greatly less than that of A. The velocity communicated from A to C through the intervention of B, is greater than the velocity communicated directly from A to C. Since, by Cor. 3, Prop. IV. vel. of $B = \frac{2Aa}{A+B}$, and velocity communicated immediately from A to $C = \frac{2Aa}{A+C}$. But by Prop. iii. § 2. p. 616. $B+C : 2B = \frac{2Aa}{A+C} : \frac{2Aa}{A+B} \times \frac{2B}{B+C}$ the velocity communicated from B to C. We must therefore prove that $\frac{2Aa}{A+C}$ is less than $\frac{2Aa}{A+B} \times \frac{2B}{B+C}$, that is, that $A+C$ is greater than $\frac{\overline{A+B} \times \overline{B+C}}{2B}$, or $2A+2C$ greater than $A+C+B+\frac{AC}{B}$, or AC greater than $B+\frac{AC}{B}$. Let us suppose $A=B+x$, $C=B+y$, then $A+C = 2B+x+y$, and $B+\frac{AC}{B} = B+\frac{B^2+Bx+By+xy}{B} = 2B+x+y+\frac{xy}{B}$, that is, $\frac{xy}{B}$ is the difference between $A+C$ and $B+\frac{AC}{B}$, and therefore if $\frac{xy}{B}$ is negative, which will always happen when x and y have different signs, that is, when B is less than one of the bodies A and C, and greater than the other, then $A+C$ is greater than $B+\frac{AC}{B}$, that is, the velocity communicated to C by means of B, is less than the velocity communicated to it directly from A.

If the bodies are in geometrical progression, and are represented by A, Ar, Ar^2, Ar^3, and if a, b, c, d, are the velocities successively communicated to them, then, if the number of bodies is n, the velocity of the first is to the velocity of the last as $(1+r)^{n-1} : 2^{n-1}$.

By Prop. iii. § 2. $A+Ar : 2A = a : b$, or
$1+r : 2 = a : b$
In like manner, $1+r : 2 = b : c$
And $1+r : 2 = c : d$

Consequently. $a : b = b : c = c : d$, and componendo $(1+r)^{n-1} : 2^{n-1} = a$: the velocity of the last.

Prop. VI.

To determine the velocities of two imperfectly elastic bodies after impact, the force of compression being in a given ratio to the force of restitution.

The only difference between the collision of perfectly and imperfectly elastic bodies is, that in the former, the force of restitution being equal to that of compression, the velocity lost by A and gained by B is equal to the velocity lost or gained during the act of compression; whereas, in the latter, these two forces have some other ratio, the force of restitution being always less than that of compression.

Let us suppose that $m : 1$ represents the ratio of imperfect and perfect elasticity, then since the velocity A, when the bodies move in the same direction, during the act of compression, is $\frac{Ba-Bb}{A+B}$, then $1 : m = \frac{Ba-Bb}{A+B} : \frac{mBa-mBb}{A+B}$ the velocity lost by the force of restitution. The sum of these two velocities, or $\frac{Ba-Bb+Bam-Bbm}{A+B} = \frac{\overline{1+m} \times A \times \overline{a-b}}{A+B}$ = velocity lost by A. By the same mode of reasoning, it may be shewn that $\frac{\overline{1+m} \times B \times \overline{a-b}}{A+B}$ = velocity gained by B.

The very same results will be obtained when the bodies move in opposite directions, with this difference only, that the sign of b must be negative. Hence it follows, that

$A+B : \overline{1+m} \times A = a-b$: vel. gained by B in the direction of A's motion.

$A+B : \overline{1+m} \times B = a-b$: vel. lost by A in the same direction.

The velocity of A after impact will therefore be

$$a - \frac{\overline{1+m} \times B \times \overline{a-b}}{A+B} = \frac{\overline{A-mB} \times a + \overline{1+m} \times Bb}{A+B}$$

and the velocity of B after impact will be

$$b + \frac{\overline{1+m} \times A \times \overline{a-b}}{A+B} = \frac{\overline{B-mA} \times b + \overline{1+m} \times Aa}{A+B}$$

Cor. 1. If B is at rest before impact, then if $A : B = m : 1$, or $A = mB$, or $A - mB = 0$, A will also be at rest after impact. Since $b = 0$, and $A - mB = 0$, the preceding expression of A's velocity after impact, will be $= 0$; that is, it will be at rest after impact.

By substituting these values in the expression of B's velocity, that is, making $A - mB = 0$, and substituting mB in place of A, we obtain $\frac{\overline{1+m} \times mBa}{mB+B} = ma$.

Cor. 2. The relative velocity before impact, viz. $a-b$, is to the relative velocity after impact, or $\beta - \alpha$, (adopting the notation in Cor. 7. Prop. IV.) as $1 : m$.

Since, by this Proposition,

$$\alpha = a - \frac{\overline{1+m} \times B \times \overline{a-b}}{A+B} \text{ and } \beta = b - \frac{\overline{1+m} \times A \times \overline{a-b}}{A+B}$$

we have $\beta - a = b - a + \frac{\overline{1+m} \times \overline{A+B} \times \overline{a-b}}{A+B} = \overline{b-a} + \overline{a-b} + m \times a - b = m \times \overline{a-b}$, the relative velocity after impact. Hence $a-b : m \times a-b = 1 : m$, or $a-b : \beta-\alpha = 1 : m$.

When the bodies move in opposite directions, their impact b has a negative sign.

Cor. 3. The sum of the products obtained by multiplying each body into the square of its velocity, is the same both before and after impact. This is demonstrated in a similar manner as in perfectly elastic bodies. See Cor. 8. Prop. IV.

Prop. VII.

If a hard spherical body impinges obliquely against another hard spherical body at rest, the velocity of the moving body after impact, will be to the velocity communicated to the other body as radius is to the cosine of the angle formed by the direction of their respective motions.

Let the body A (Plate CCCLXIII. Fig. 11.) moving in the direction MAN strike the body B at rest. The impact obviously takes place at the instant when the distance AB of the bodies is equal to the sum of the radii, and it is manifest that AB will be the direction of the motion of B after impact. Let AP be the direction of A after impact, and let us suppose, that during the momentary continuance of the stroke, the two bodies describe spaces infinitely small, viz. A a and B b. Join $a\,b$, and since the two bodies must continue to touch each other without any change of form, (from their being perfectly hard,) we shall have $a\,b$ = AB. From the point b with the radius b A, describe an infinitely small arc A m, joining the sides b A, $b\,a\,m$, which contains the infinitely small angle A $b\,m$. Then, since BA = $b\,a$, and b A = $b\,m$, we have, by subtracting the former from the latter, B b = $a\,m$. Now, as we may consider $a\,m$ A as a rectilineal triangle, having a right angle at m, we have A a : $a\,m$, or B b = rad. : sin. a A m = rad. = : cos. BAP. But as A a and B b are the velocities of A and B at the instant the impact is finished, they will also be their velocities after impact; and, therefore, the velocity of A after impact, is to the velocity of B as radius is to the cosine of the angle formed by the direction of their respective motions.

Prop. VIII.

To determine the velocities after impact, when a hard spherical body impinges obliquely against another hard spherical body at rest.

Let AN, Fig. 11. represent the velocity of A before impact, AP its velocity after impact, and AC the velocity of B after impact. Then, if we complete the parallelogram APND, it is obvious that the velocity of A before impact, viz. AN, may be resolved into AP and AD; but as it has only the velocity AP, AD must be the velocity which it loses, and by which it gives motion to B. Then, since the line AD coincides with AC, we have A×AD = B×AC. Now,

Let the given velocity of A, viz. AN $= a$
Sine of BAN, the given angle $= m$
Cosine of BAN $= n$
The required velocity AN $= x$
Sine of NAP $= y$
Cosine of NAP $= z$

Then, since BAP = BAN + NAP, we have sin. BAP or APN $= m\,z + n\,y$, and cos. BAP $= n\,z - m\,y$. But from the proportionality between the sines and the sines of the opposite angles of the triangle ANP, we shall obtain AD thus, $m : y = x : \frac{x\,y}{m} =$ AD. We have also AC = AP × cos. BAP $= x\,(n\,z - m\,y)$. But since A × AD = B × AC, we have, by substituting the above values in this equation, $\frac{\mathrm{A}\,x\,y}{m} = \mathrm{B}\,x\,n\,z - \mathrm{B}\,x\,m\,y$, which dividing by x, and multiplying by m, becomes $\mathrm{A}\,y = \mathrm{B}\,m\,n\,x - \mathrm{B}\,m^2 y$, and bringing the terms containing y to one side of the equation, and substituting for z its value $\surd\,(1 - y^2)$ (for since $z^2 + y^2 = \mathrm{rad.}^2$ we have $z^2 = \mathrm{rad.}^2 - y^2$, and $z = \surd(1 - y^2)$) and then squaring both sides, we obtain $y = \frac{\mathrm{B}\,m\,n}{\surd((\mathrm{A} + \mathrm{B}\,m^2)^2 + \mathrm{B}^2 m^2 n^2)}$ and substituting the value of y in the equation $\surd\,(1 - y^2)$ we shall have $z = \frac{\mathrm{A} + \mathrm{B}\,m^2}{\surd((\mathrm{A} + \mathrm{B}m^2)^2 + \mathrm{B}^2 m^2 n^2)}$.

But in the triangle ANP, we have sin. ANP, or sin. BAN : sin. ANP = AP : AN; that is, $m : m\,z + n\,y = x : a$, and $x = \frac{a\,m}{m\,z + n\,y}$. Hence, by substituting the values of y and z in this equation, and considering that $m^2 + n^2 = \mathrm{Rad.}^2 = 1$, we shall obtain $x = a\,\frac{\surd\,((\mathrm{A} + \mathrm{B}m^2)^2 + \mathrm{B}^2\,m^2 n^2)}{\mathrm{A} + \mathrm{B}}$. Having thus obtained the direction, and the velocity of the body A after impact, the velocity AC of the body B after impact, will be found from the equation AC = AP × cos. BAP, or AC may be found geometrically, by letting fall from P the line PC, perpendicular to AC.

Prop. VIII.

When a perfectly hard body strikes a fixed plane, also perfectly hard, the body will move along the plane after impact, and the velocity after impact will be to the velocity before it as the sine of the angle of incidence is to radius.

Let MN (Plate CCCLXIII. Fig. 12.) be the hard and fixed plane, and let the body, moving with an uniform velocity in the direction AB, strike the plane at B, it will move on in the direction BN after impact, and its velocity after impact will be to its velocity before it, as AC is to AB. The motion of the body in the direction AB may be resolved into two, in the directions AC and CB. The motion represented by CB being perpendicular to the plane MN, will be wholly destroyed after impact, as the plane is fixed, and therefore the body will advance after impact in the direction BN, in virtue of the motion, in the direction AC, parallel to BN, which is not altered by impact, and will describe BN or AC, in the same time that it described AB. Hence the velocity after impact is to the velocity before it as AC is to AB; that is, as the sine of the angle of incidence ABC is to radius AB.

Cor. 1. The velocity lost by impact is to the velocity before impact, as the versed sine of the complement of the angle of incidence is to radius. For AB — AC, (the velocity lost,) : AB = Rad. — Cos. ABM : Rad.; that is, as the versed sine of ABM (or complement of the ∠ of incidence) is to radius.

Cor. 2. If the body strikes the plane perpendicularly, the whole of its velocity will be destroyed, and it will remain at rest.

PROP. IX.

To determine the velocities after impact, when an elastic body impinges against another elastic body at rest.

Having determined the velocities AP, AC, (Plate CCCLXIII. Fig. 11.) as in Prop. VII. as if the bodies were both perfectly hard, prolong NP to p, and make NP=2 NP, then joining p, A, and taking A n=2 AC, the velocities after impact will be represented by the lines A p, A n. For since NP is the velocity lost by A, and AC the velocity gained by B, when they are hard, the double of these quantities, viz. Np and A n, will be the velocities lost and gained when the bodies are elastic. Hence, since B was at rest, the lines A p and A n will express the velocities of the two bodies after impact.

PROP. X.

If a body perfectly elastic impinges against a fixed plane, that is perfectly hard, it will be reflected from it in such a manner that the angle of reflection is equal to the angle of incidence.

Let MN, (Plate CCCLXIII. Fig. 12.) be the plane, and let AB represent the motion of the body. Through A draw AD parallel to MN, and making CD=CA join B, D. The motion AB being resolved as formerly into AC, parallel to the plane MN, and BC perpendicular to it, the former AC will continue after impact, while the latter BC will be destroyed by impact. The force of restitution, however, will create an equal motion, BC, in the opposite direction, and in virtue of this new motion, combined with CD=AF, the body will move in the diagonal BD, and will describe BD in the same time that it described AB. But since AC=CD, and ACB=BCD, the triangles ACB, DCB, are equal, and the angle of incidence ABC equal to the angle of reflection CBD

COR. As the motion generated by the force of restitution is exactly equal to that which is lost by impact, the velocity of the body after reflection is equal to its velocity before it.

PROP. XI.

If an imperfectly elastic body impinges against a fixed plane perfectly hard, the tangent of the angle of reflection will be to the tangent of the angle of incidence, as the force of compression is to the force of restitution; and the velocity after reflection will be to the velocity before it, as the sine of the angle of incidence is to the sine of the angle of reflection.

Take B c to BC, (Fig. 12.) as the force of restitution is to the force of compression; then, since the impinging body receives from the force of restitution a motion equal only to B c, this motion, when compounded with its motion $c\,d$=CD, will produce a motion in the direction B d; and since, when BC is radius, CD=$c\,d$ is the tangent of the angle CBD=ABC, the angle of incidence, and C δ, the tangent of the angle of reflection, we have, on account of the parallelism of $c\,d$, CD, CD : C δ=B c : BC; that is, the tangents of the angles of incidence and reflection are to one another as the forces of restitution and compression. The velocity after reflection being to the velocity before it as B d to BA, we have B d : BA=B d : BD d=sin. B d D, (or CB d its supplement,) : BD d, (or CBD,)=sin. CB d : sin. CBA.

PROP. XII.

To determine the velocities and the directions of the motions of two perfectly hard bodies that impinge against each other.

Let AC, BC, (Plate CCCLXIII. Fig. 13.) represent the velocities of the two bodies, supposed to be very small, and the directions in which they move. Join A, B, and through B draw MN perpendicular to AB, and MN will be the section of a plane which will touch both bodies at their point of contact, as it is always perpendicular to a line joining their centres. The velocity AB may be resolved into Aa parallel to the plane, and Ca perpendicular to it; and the velocity BC into Bb parallel to the plane, and Cb perpendicular to it. In virtue of the two velocities C a, C b, with which the bodies may be supposed to impinge upon one another directly, they will have a common velocity after impact, which we may call CD, (as determined by Prop. II. p. 616.) The body A may therefore be conceived to be animated with velocities CG, taken equal and parallel to A a and the common velocity CD; and in virtue of these it will describe the diagonal CH. In like manner the body B, supposed to be animated by the velocity CE, taken equal and parallel to B b, and the common velocity CD, will describe the diagonal CF. The lines CH and CF will therefore represent the velocities and directions of the two hard bodies A and B after impact.

PROP. XIII.

To determine the velocities and the direction of the motions of two perfectly elastic bodies that impinge against each other.

Let A, B, (Plate CCCLXIII. Fig. 14.) be the two bodies, then instead of finding their common velocity, as in the case of hard bodies, find the velocities of each arising from the direct part of the impact, and let C d be the velocity of A, and Cδ that of B; then by combining these velocities with C f, and C g, the velocities of the bodies parallel to the plane MN, we shall have C e and C h for the quantities and the directions of the velocities after impact.

When the bodies are imperfectly elastic, the very same method is to be followed, substituting the velocities after the direct impact, as found in Prop. VI. p. 619.

In the last two propositions we have supposed the spherical bodies to have such small diameters, that the lines passing through their centres, and drawn parallel to MN, might be supposed to coincide with that line. The method of finding the velocities and the directions of the bodies after impact, however, is not greatly altered when the diameters have a sensible magnitude.

CHAP. IV.

ON THE ROTATION OF BODIES.

In the preceding section we have considered only the effects produced by the collision of spherical bodies, which, whatever be the direction in which they impinge upon one another, have only a progressive motion after impact. As these bodies are supposed to be homogeneous, their centre of gravity coincides with the centre of their figure, and as the points in which they strike one another, must always be in a line joining their centres, the force passes through the centre of gravity of the two bodies, and therefore this centre must move either forwards or backwards, according to the circumstances of the case.

If the body which is struck is not spherical, the force with which it is struck by another body, must often be directed in a line which does not pass through its centre of gravity, and therefore it becomes of importance to ascertain the effects which will be produced under these new circumstances.

Let CD (Plate CCCLXIII. Fig. 16.) be a plane passing through the centre of gravity of the body, and let it be struck in the direction FK by another body, and with a force represented by FA. Through the centre of gravity G, draw GV perpendicular to the plane CD, and through G draw SGK perpendicular to FK. Bisect FA at B, and upon BF construct the parallelogram FEBN, one of whose sides FN passes through the centre of gravity G, while the other FE is at right angles to FB. The force FB, which is one-half of the whole force FA, may be resolved into FN and FE. Having prolonged FG to L, and made $GL = GF$, take $LO = FN$, and suppose that the force FN is applied to the point L of its direction. This force may then be resolved into LP, LM, one parallel and the other perpendicular to SGK. Having thus transferred a part of half the force FA to the point L in the direction LO, we may now conceive the body CD to be acted upon by the original force FA, distributed in the following manner, namely, by BA acting in that direction, and by FE on one side of the centre of gravity, and by LM and LP acting on the other side; but as $BA = BF$, is equal to LM, on account of the equal triangles FBN, LMO, and is also parallel to it, it will, by STATICS, Prop. II. Cor. 4. have for their resultant a force GQ parallel to each of them, and passing through the centre of gravity G, and equal to $BA + LM$. Hence, since $FA = 2BA$, we have $GQ = FA$. It follows, therefore, that in virtue of the two forces FB, LM, the centre of gravity G is moved in a direction parallel to FA, or in the same manner as if the direction of the force FA passed through the centre of gravity G.

Let us now proceed to consider the effect of the remaining forces FE and LP These forces are obviously equal and parallel, and exerted in opposite directions and at equal distances from the centre of gravity G. They cannot, therefore, have any tendency to give the centre of gravity a motion either towards the one or towards the other; that is, the centre of gravity will remain at rest in so far as it is influenced by these equal and opposite forces. But as these two forces are not directly opposed to one another, they must therefore tend to turn the body CD round its centre of gravity G, with forces proportional to the perpendiculars GI, GH, let fall from G upon the line of directions PI, EH. Now, since $GI = GH$, the effect of the force LP acting at the point I upon the lever GI, is the same as if it were applied in the opposite direction HE to the point H. Hence, the effect of the two forces FE, LP, to turn the body round G, is equal to $FE + LP \times GH = 2\ FE \times FK = 2\ BN \times FK$. But in the similar triangles FKG, FBN, we have $FK : FB = GK : BN$, and $FK \times BN = FB \times GK$. Consequently, $2\ BN \times FK = 2\ FB \times GK = FA \times GK$, which expresses the momentum of the force FA to turn the body round G, and therefore it follows, that the body will turn, at least during the first instant, as if the centre of gravity were fixed, round an axis GV passing through the centre of gravity, and perpendicular to a plane passing through the same centre, and through the line representing the direction of the force.

If the plane which contains the direction of the force does not divide the body CD into two equal parts, the motion of the centre of gravity will continue the same as before; but the axis of rotation GV, instead of being fixed as before, will incline itself on all sides, and the body will whirl in different directions round its centre of gravity.

PROP. I.

When a perfectly hard body strikes another body perfectly hard, in a direction which does not pass through its centre of gravity; to determine the momentum communicated to each particle, the velocity of the centre of gravity, the velocity of rotation of any point of the body, and the velocity of the striking body after impact.

Let the body A (Plate CCCLXIII, Fig. 17.) strike the body CD in a direction AK which does not pass through its centre of gravity G, and let the line AK lie in a plane passing through G, and dividing the body into two equal parts. Let Aa be the space which A describes in an infinitely small space of time before impact, and $A\,b$ the space which it describes after impact, in consequence of the resistance or re-action of the body, and let $G\,g$ be the infinitely small space described by the centre of gravity G, in a direction parallel to AK, while in the same time it describes the infinitely small angle $h\,g\,i$ round its axis $G\,V$, now carried to $g\,u$. From G draw GK perpendicular to AK, and consequently perpendicular to GV. Now, since A would have described the space Aa, but for the re-action of G, which reduces it to $A\,b$, $A \times b\,a$ will represent the motion lost by A, and $G \times G\,g$ the motion in the direction $G\,g$ gained by G But since the centre of gravity G moves in the same manner as in cases of collision, when the direction of the force passes through the centre of gravity, we shall have $A \times b\,a = G \times G\,g$; and considering G as immoveable, the force lost by A in relation to the axis GV, will be $A \times b\,a \times GK$. Now let p be any particle of the body CD which describes the small arc $p\,y$, at the distance $g\,p$ from the centre of gravity G, transferred to g, while a given point h describes the small arc $h\,i$ at — the distance $g\,h$; then, if we take $h\,i$ to represent the velocity of rotation of the point h, the velocity $p\,y$ of the particle p, will be $g\,p \times \frac{hi}{gh}$. The motion gained by the particle p will therefore be $\frac{p \times g\,p \times hi}{gh}$, and the quantity of this motion relative to the axis $g u$ will be $\frac{p\times g p\times h i}{g h}\times g\ p = p\times g\ p^2 \frac{h i}{\times g h}$. Hence it follows, that the momentums gained by each particle is equal to the particle multiplied by the square of its distance from the axis of rotation,* and by the constant quantity $\frac{h i}{g h}$.

But since every particle of the body CD has a momentum expressed in a similar manner, if we call p any particle, and $r = p g$ its radius vector, or distance from the axis of rotation, we may express the sum of the products of all the particles by the squares of their distances from the centre of rotation by $\int p\, r^2$, and therefore the quantity of motion gained by the body CD will be expressed by $\int p\, r^2 \times \frac{h i}{g h}$, and we shall then have $A \times b a \times GK = \int p\, r^2 \times \frac{h i}{g h}$. If we now make $G =$ mass of the body CD, $b = GK$, $V =$ the velocity of the body A before impact, x its velocity after impact, $y =$ the velocity Gg of the centre of gravity G, $d =$ the distance $g h$, and $z =$ velocity of rotation $h i$ of the point h, we shall have $A\,(V - x) = G\, y$; $A \times (V - x)\, b = \int \frac{r^2 z}{\;}$, which multiplying by d becomes $A\,(V - x)\, b\, d = \int p\, r^2 z$. As the body A is necessarily in contact with CD during impact, then if $g k$ is parallel to GK, $k n$ will be the arc described by the point k, whilst h describes $h i$, and since therefore $A\, b = K n$. But since $k n : h i = g k$ (or GK) $: g h$, we have $k n : z = b : d$, and $k n = \frac{b z}{d}$; and as $k n = K n - G g$, we have $K n - G g = \frac{b z}{d}$ and $K n = G g \times \frac{b z}{d}$ or $x = y \times \frac{b z}{d}$. From these three equations, containing values of x y and z, we shall obtain

$$x = \frac{A \cdot V\,(\int p\, r^2 + b^2 G)}{(A+G)\int p\, r^2 + b^2\, A.G}$$

$$y = \frac{A.V\,(\int p\, r^2)}{A+G\,(\int p\, r^2) + b^2 A.G}$$

$$z = \frac{A.V.b.d\, G.}{A+G\,(\int p\, r^2) + b^2 A.G}$$

The two motions of translation and rotation thus communicated to the body CD, are independent of one another, and the one may be conceived to be extinguished without the other being completely destroyed. If we suppose, for example, the centre of gravity G to be opposed by a resisting force equal to $G \times y$, the motion of translation of the body G will be completely destroyed without any change being produced upon the rotatory motion. This effect is very finely exemplified in cannon balls, which have often a motion round their axis, along with a progressive motion. When the ball has fallen, and has apparently lost all its motion, it is often found to be wheeling rapidly round a vertical axis. If in this situation it meets with resistance from a stone, or any other body, its axis of rotation will decline from the vertical, and become horizontal; and the motion of rotation will thus produce a new progressive motion, which often carries the ball forward with a degree of force that is frequently dangerous.

If we compare the two preceding values of y and z, it will be obvious that $z : y = b\, d\, G : \int p\, r^2$; that is, the velocity of rotation of any point p is to the velocity of translation of the centre of gravity G, in a ratio which is the same, whatever be the magnitude of the force by which these two motions are impressed. Since, from the above analogy, we have $d = \int \frac{p\, r^2 z}{y\, G\, b}$ it follows, that if any body, such as a planet, is put in motion by a force the direction of which passes at a distance from its centre of gravity, equal to $\int \frac{p\, r^2 z}{y.\, G.\, b.}$ it will receive from that force the two motions of translation and rotation.

The limits of this article will not permit us to point out the application of the preceding formulæ to bodies of particular forms. We have only to find the value of $\int p\, r^2$ geometrically, and multiply it by the density of the body.

PROP. II.

If a body revolves round a fixed axis by the action of any given force, the force which accelerates the point to which the force given is applied, is equal to the quotient arising from dividing the product of the force into the square of the distance by $\int p\, r^2$, or the sums of the products of all the masses or particles into the square of their distances from the axis of motion.

Let f be the given force applied at the distance d from the axis of motion, then since the momentum of any particle p at the distance r is equal to $p \times r^2$, the momentum of the same particle at the distance d, will be obtained from the analogy $d^2 : r^2 = p : \frac{p \times r^2}{d^2}$, consequently, $\int \frac{p\, r^2}{d^2}$ will express the momentum of all the particles in the body at the distance d, or the mass put in motion by the force f. But the accelerating force is equal to the quotient of the moving force by the mass moved, and therefore we have the accelerating force $= \int \frac{f\, d^2}{p\, r^2}$.

COR. The angular velocity generated in a given time by the force f at the distance d, is as $f \times d \div \int p\, r^2$. For the absolute velocity of the point to which the force f is applied is as the accelerating force, and the angular velocity is directly as the absolute velocity and inversely as the distance, consequently, the angular velocity is as $\int \frac{f d^2}{p r^2} \times \frac{1}{d}$ or as $f \times d \div \int p r^2$.

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* The following is the usual way of expressing and demonstrating this fundamental truth in rotatory motion. If a body revolves round a fixed axis, the particles of matter which compose it, resist the communication of motion to any given point of the body, with forces which are in the compound ratio of the particles, and the squares of their distances from the axis of motion.

Let P, (Fig. 15.) be a force applied at the distance OP from the axis of rotation O, to communicate motion to a body consisting of particles A, B, C, and revolving round O at the distances a, b, c, from O. Let x be the quantity of matter, which would have the same effect in resisting the communication of motion to the point P by virtue of its inertia, as if the particle A were removed, and let M and m be the momentum of the forces thus applied to A and P, and V v the velocities of A and p. Then, since x and P may represent the quantities of matter, we have $x : p = \frac{M}{V} : \frac{m}{v}$; but the effect of the moving forces M and m to put a body in motion at the points A and P are inversely as the distances OP, OA, that is, $M : m = \frac{1}{OA} : \frac{1}{OP}$. But $V : v = OA : OP$. hence $x : P = \frac{1}{OA \times OA} : \frac{1}{OP \times OP}$, or $x : P = OP^2 : OA^2$ and $x \times OA^2 = P \times OP^2$

Definition. The **Centre of Oscillation** is that point in a compound pendulum or system of matter revolving round a fixed axis, in which, if all the matter were collected, any force applied at this centre will generate the same angular velocity in a given time, as the same force applied at the centre of gravity.

Since the force of gravity may be regarded as a force applied to the centre of gravity of a pendulum, the centre of oscillation will be that point in a pendulum in which, if all the matter were concentrated, so as to vibrate round the same axis of motion, its vibrations would be performed in the same time as those of the compound body.

Prop. III.

If a compound pendulum or system of bodies vibrates about a fixed axis by the force of gravity, the distance of the centre of oscillation from the axis is equal to the quotient arising from dividing the sum of the products of each particle into the square of its distance from the axis, by the product of the weight of the whole body into the distance of its centre of gravity from the axis of motion.

If we call x the distance of the centre of oscillation from the axis of motion, and g the distance of the centre of gravity, then if a force f is applied at the distance g, the force which accelerates the centre of gravity will be $\frac{g^2 f}{\int p r^2}$, and as the accelerating force varies as the distance from the axis, we have $g : x = \frac{g^2 f}{\int p r^2} : \frac{g x f}{\int p r^2}$, the force which accelerates the centre of oscillation when the force f is applied to the centre of gravity. Let us now suppose that all the matter is collected in the centre of oscillation, and that the moving force f is applied there, then since the accelerating force is equal to the quotient of the moving force by the mass moved, we have the force which accelerates the centre of oscillation $= \frac{f}{\int p}$. But since the angular velocity, when the motion is collected in the centre of gravity, is, by hypothesis, equal to the angular velocity when the matter is concentrated in the centre of oscillation, the accelerating forces by which these equal angular velocities are produced, must also be equal, and therefore we obtain $\frac{g x f}{\int p r^2} = \frac{f}{\int p}$ and $x = \frac{\int p r^2}{g \times \int p}$, the distance of the centre of oscillation from the axis; that is, the distance of the centre of oscillation is equal to the sum of the products found by multiplying each particle by the square of its distance from the axis of motion, divided by the product of the force of gravity, or the weight of the whole of the body, or the sum of all the particles by the distance of the centre of gravity from the same axis.

Cor. A simple pendulum, consisting of a heavy point suspended by a slender thread or fibre, and having the distance of the heavy point of the ball from the axis of suspension equal to x, or the distance of the centre of oscillation from the point of suspension, will perform its vibrations in the same time as any system of matter which has the distance of its centre of oscillation equal to x. Hence, this pendulum is called the *equivalent* or *synchronous pendulum*.

Scholium.

The centre of oscillation in bodies of various forms may be easily determined by a very simple fluxional process, similar to that which we have already explained for the centre of gravity. We have only to multiply any particle of matter by the square of its distance from the axis of suspension, and the quotient arising from dividing the sum of all these products by the product of the whole weight into the distance of the centre of gravity from the axis, will be the distance of the centre of oscillation from the axis of suspension. The following are some of the principal results.

1. If the body is a heavy straight line of uniform density, and is suspended by one extremity, the distance of its centre of oscillation is 2-3ds of its length.

2. A slender rod of a cylindrical or prismatic shape, whose breadth is very small compared with its length, has the distance of its centre of oscillation nearly 2-3ds of its length from the axis of suspension. If these rods were formed so that all the points of their transverse sections were equidistant from the axis of suspension, the distance of the centre of oscillation would be exactly 2-3ds of their length.

3. In an isosceles triangle, suspended by its apex, and vibrating in a plane perpendicular to itself, the distance of the centre of oscillation is 3-4ths of its altitude.

4. As a line or rod whose density varies as the distance from its extremity, or the point of suspension, is in precisely the same predicament as the isosceles triangle in Case 3, the distance of its centre of oscillation will be also 3-4ths of its length.

5. In a very slender isosceles triangle, whose base is very small compared to its altitude, the distance of its centre of oscillation will be nearly 3-4ths of its length, in whatever direction it swings.

6. In a cone suspended from its apex, and having its axis in the plane of vibration, the distance of its centre of oscillation will be $\frac{4+n^2}{5} a$; a being its altitude, and $n a$ the radius of its base. If $n = 1$, in which case the altitude of the cone is equal to the radius of its base, and the cone is right angled, its centre of oscillation will be in the centre of its base. If $n > 1$, in which case the angle of the cone is obtuse, the centre of oscillation will fall below the base. If $n < 1$, in which case the cone is acute angled, the centre of oscillation will fall above the base.

7. In a very slender cone or pyramid vibrating about its apex, the distance of its centre of oscillation is nearly 4-5ths of its length.

8. In a sphere whose radius is r, suspended from a point on its surface by a string without weight, whose length is l, the distance of its centre of oscillation from its centre of suspension, will be $l + r + \frac{2 r^2}{5(l+r)}$, and the distance between its centre of bulk and oscillation will be $\frac{2 r^2}{5(l+r)}$. Hence, in a pendulum vibrating seconds in

the latitude of London, whose length is 39.1386, according to Captain Kater, and with a ball whose radius is *one* inch, we shall have $l+r+\frac{2\,r^2}{5(l+r)}=39.1386$, by the reduction of which we shall obtain $l=38.1284$ and $\frac{2\,r^2}{5(l+r)}=\frac{1}{97.8}=0.0102$ of an inch. If $l=r$, then the distance of the centres of oscillation and suspension will be $\frac{1}{5}r$.

9. If the thread or string is supposed to have weight, then calling $a=l+r$, $d=$ diameter of the ball, $w=$ the weight of the thread, and W that of the ball, we have the distance of the centres of oscillation and gravity $=\frac{(\frac{1}{3}\,w+\frac{2}{5}\mathrm{W})\,d^2-\frac{1}{6}\,w\,(a\,d+a^2)}{(\frac{1}{2}\,w+\mathrm{W})\,a-\frac{1}{2}\,d\,w}$

10. In a circular plane, the distance between the centres of oscillation and suspension will be $l+r+\frac{r^2}{2\,(l+r)}$. If the point of suspension is in the circumference of the circular plane, then $l+r=r$, and the distance required will be $r+\frac{r^2}{2\,r}=1\ r$.

11. In a pendulum with a lenticular weight, the distance between the centre of oscillation and the centre of the lenticular weight will be $\frac{\frac{2}{3}\,d\,r^2-\frac{1}{2}\,d^2\,r+\frac{1}{10}\,d^3}{a(r-\frac{1}{2}\,d)}$ where r is the radius of the sphere to which the lenticular weight belongs, and $a=$ the distance between the point of suspension and the centre of the lenticular weight.

PROP. IV.

If a compound pendulum is so constructed that it can be suspended, and made to vibrate about its centre of oscillation, the centre of suspension will become the centre of oscillation.

Let SO (Fig. 1. Plate CCCLXIV.) be the distance between the centre of oscillation O, and that of suspension S, and SG the distance of the centres of oscillation and gravity, and p any particle of the pendulum. From p draw $p\,a$, perpendicular to SG, then in the formula of Prop. III. $x=\frac{\int p\,r^2}{g\times\int p}$ or $g\,x=\frac{\int p\,r^2}{\int p}$, resuming $\mathrm{SO}=r$, and $\mathrm{SG}=g$, and $\int p\times \mathrm{S}p^2=\int p\,r^2$, and $w=\int p$, we obtain $\int p\times \mathrm{S}p^2=w\times\mathrm{SO}\times\mathrm{SG}$. But by GEOMETRY, Prop. XII. and XIII. $\int p\times \mathrm{S}p^2=\int p\times p\,\mathrm{O}^2\times\int p\times\mathrm{SO}^2-\int p\times\mathrm{SO}\times 2\,\mathrm{O}\,a$, and therefore $w\times\mathrm{SO}\times\mathrm{SG}=\int p\times p\,\mathrm{O}^2+\int p\times\mathrm{SO}^2-\int p\times\mathrm{SO}\times 2\mathrm{O}\,a$. But $\int p\times\mathrm{SO}^2=w\times\mathrm{SO}^2$, and by the property of the centre of gravity, $\int p\times\mathrm{SO}\times 2\mathrm{O}\,a=w\times\mathrm{SO}\times 2\,\mathrm{OG}$; and, therefore, by substituting these values in the preceding equation, we have

$$w\times\mathrm{SO}\times\mathrm{SG}=\int p\times p\,\mathrm{O}^2+w\times\mathrm{SO}^2-w\times\mathrm{SO}\times 2\,\mathrm{OG},$$

and $\int p\times p\,\mathrm{O}^2=w\times\mathrm{SO}\times\mathrm{SG}+w\times\mathrm{SO}\times 2\,\mathrm{OG}-w\times\mathrm{SO}^2$

$$=w\times\mathrm{SO}\,(\mathrm{SG}+2\,\mathrm{OG}-\mathrm{SO}.)$$

But

$$\mathrm{SG}+2\,\mathrm{OG}=\mathrm{SO}+\mathrm{OG},$$

and

$$\mathrm{SG}+2\,\mathrm{OG}-\mathrm{SO}=\mathrm{OG}.$$

Hence

$$\int p\times p\,\mathrm{O}^2=w\times\mathrm{SO}\times\mathrm{OG},$$

and

$$\mathrm{SO}=\frac{\int p\times p\,\mathrm{O}^2}{w\times\mathrm{OG}}$$

which is the property of the centre of oscillation; and therefore the centres of oscillation and suspension are convertible, O being the centre of oscillation when S is the centre of suspension, and S the centre of oscillation when O is the centre of suspension.

The same result might have been obtained, perhaps more simply, by finding, in terms of $p\,\mathrm{G}$ and SG, the value of $\mathrm{GO}=\frac{\int p\times p\,\mathrm{G}^2}{w\times\mathrm{SG}}$, and $\mathrm{SG}\times\mathrm{GO}=\frac{\int p\times p\,\mathrm{G}^2}{w}$. Hence it follows that $\mathrm{SG}\times\mathrm{GO}$ is a constant quantity, independent of the position of S and O. Consequently, since the point G is invariable in the same body, it follows that, if O is the centre of oscillation, and S that of suspension, S must be the centre of oscillation, when O is the centre of suspension.

SCHOLIUM.

If a pendulum is constructed in such a manner as to have a knife edge for its centre of suspension, and another knife edge near its centre of oscillation, and if the last knife edge is shifted by means of a screw till the vibrations of the pendulum are isochronous when performed round both these axes, the distance between the knife edges will be the exact distance between the centres of oscillation and suspension, and if the pendulum vibrates seconds, this distance will be the true length of the pendulum for the latitude in which it vibrates. Upon this principle is founded the ingenious method of measuring the length of the pendulum, which has been so successfully practised by Captain Kater, and which he has described in the *Phil. Trans.* for 1818.

DEFINITION.—The CENTRE OF PERCUSSION is the point in a body revolving round a fixed axis, so taken that, when it is stopped by any force, the whole motion, and tendency to motion, of the revolving body is stopped at the same time. It is also that point of a revolving body which would strike any obstacle with the greatest effect, and from this property it has received its name.

Let us suppose that MN, (Fig. 2. Plate CCCLXIV.) a body moving parallel to itself, and that it strikes the obstacle G, which is the centre of gravity of MN. Then we may conceive MN to be a lever, and G its fulcrum, and therefore the whole of the motion of MG will be stopped when the obstacle at G is struck, for no reason can be assigned why any one point of the body shall advance rather than another. If the body MN is now struck at any other point g, which does not bisect MN, then, considering it again as a lever whose fulcrum is g, it is manifest, that as the momentum of gN is greater than that of g M, the body will have a rotatory motion round g as a centre. If the body is now supposed to revolve round S, Fig. 3. let G, be its centre of gravity, so that SG=GN. If the body SN is now opposed by an obstacle at G, its middle point, its whole motion will not be destroyed as formerly; for though G is its middle point, yet, as all the particles in the lower half GN have a greater velocity than those in the upper half, the lower half has more motion than the upper half, and therefore the body has a tendency to turn round G, and would do it, if it were released from its point of suspension AS. In order, therefore, that all the motion of the body SN may be destroyed, the obstacle must be placed at such a point O, for example, that the sum of the momenta of all the particles between O and S is equal to the sum of the momenta of all the particles between O and N.

PROP. V.

The distance of the centre of percussion from the centre of suspension, is the same as the distance of the centre of oscillation; the centre of percussion being required in a plane passing through the centre of suspension and the centre of gravity.

Let ABC, (Fig. 3. Plate CCCLXIV.) be a plane passing through the centres of suspension and gravity, and let all the particles of the body be supposed to be projected upon this plane, in the direction of lines perpendicular to it. Let S be the centre of suspension, G the centre of gravity, and O the centre of oscillation, and let p be the place of one of the particles. The absolute velocity of p, when revolving round S, will be expressed by p S, and its quantity of motion will be $p \times p\,\mathrm{S}$, acting in the tangential direction p R. Continue p R, and draw OD parallel to p S, and meeting p R in D. The force $p \times p\,\mathrm{S}$, if employed to move the system round O, will be $p \times p\,\mathrm{S} \times \mathrm{OD}$. But in the similar triangles SpR, COD, we have $\mathrm{OD} = \frac{\mathrm{S}p \times \mathrm{RO}}{\mathrm{SR}}$, and as $\mathrm{RO} = \mathrm{SO} - \mathrm{SR}$, we obtain $\mathrm{OD} = \mathrm{S}p\frac{\mathrm{SO} - \mathrm{SR}}{\mathrm{SR}}$. Hence, drawing $p\,a$ perpendicular to SO, we have on aocount of the similar triangles SpR, S$p\,a$, $\mathrm{S}a = \frac{\mathrm{S}p^2}{\mathrm{SR}}$, and therefore by substitution we have $p \times \mathrm{S}p \times \mathrm{OD} = p \times \mathrm{S}p^2 \times \frac{\mathrm{SO} - \mathrm{SR}}{\mathrm{SR}} = p \times \mathrm{S}a \times \mathrm{SO} - \mathrm{S}p^2$. But when O is the centre of percussion, the sum of the forces of each particle must be equal to nothing, since they are by hypothesis annihilated; that is, $\int p \times \mathrm{S}a \times \mathrm{SO} - \int p \times \mathrm{S}p^2 = 0$, or $\int p \times \mathrm{S}a \times \mathrm{SO} = \int p \times \mathrm{S}p^2 = \int p\,r^2$. Hence $\mathrm{SO} = \frac{\int p\,r^2}{\int p \times \mathrm{S}a} = \frac{\int p\,r^2}{g \times \int p \times g}$, the very same value which was found in Prop. III. for the distance of the centre of oscillation from the centre of suspension.

DEFINITION. The **CENTRE of GYRATION** is that point of a revolving body in which if all the matter were concentrated, any point to which a given force is applied, would be accelerated in the same manner as when the particles of the body revolve in their proper places, and therefore the angular velocity generated in a given time, will be the same in both cases.

When the axis of motion passes through the centre of gravity, then the centre thus described is called the *Principal Centre of Gyration.*

PROP. VI.

The distance of the centre of gyration from the centre of suspension, is equal to the square root of the quotient arising from dividing the sum of the products of each particle of matter into the square of its distance from the centre of suspension, by the weight of the whole body.

Let Q, Fig. 3. be the centre of gyration, and S the centre of suspension then if a force F is applied at the distance Sa, the accelerating force will, by Prop. II. be $\frac{\mathrm{F} \times \mathrm{S}a^2}{\int p\,r^2}$. Let all the matter of the body be now collected at the point R, so that the force F which accelerates the point a is the same as before, then we shall have $\frac{\mathrm{F} \times \mathrm{S}a^2}{\int p\,r^2} = \frac{\mathrm{F} \times \mathrm{S}a^2}{\int p \times \mathrm{SQ}^2}$, which, by reduction, becomes $\mathrm{SR} = \sqrt{\frac{\int p\,r^2}{\int p}}$; that is, the distance of the centre of gyration from the centre of suspension is equal to the square root of the quotient arising from dividing the sum of all the particles, multiplied by the square of their distances from the centre of motion, by $\int p$, the weight of the body, or the sum of all the particles.

COR. Since $\mathrm{SQ} = \sqrt{\frac{\int p\,r^2}{\int p}}$ and $\mathrm{SO} = \frac{\int p\,r^2}{\int p \times \mathrm{SG}}$ we have $\mathrm{SO} \times \mathrm{SG} = \mathrm{SQ}^2$ and $\mathrm{SO} : \mathrm{SQ} = \mathrm{SQ} : \mathrm{SG}$; that is, the centre of gyration is a mean proportional between the centres of gravity and oscillation.

At the beginning of the present section, we have considered the relation between the progressive and rotatory motion of a body in free space, when struck in a direction which does not pass through its centre of gravity. We have seen that when the body = CD (Plate CCCLXIII.) Fig. 17. is struck in the direction AK, the centre of gravity G advances in a direction Gg parallel to AK, while the whole mass receives a rotatory motion round the centre of gravity. Hence, when the centre of gravity is at g, the body CD will have taken a new position C′D′. It is therefore obvious, that at the commencement of the motion, the body CD must have begun to revolve round the point S. This point is called the **CENTRE OF SPONTANEOUS ROTATION**, or the centre round which a body or system of bodies has at every instant a tendency to revolve, when struck by a force whose direction does not pass through the centre of gravity.

PROP. VII.

If a body suspended on a fixed axis receives a rotatory motion by being struck at the centre of percussion, then if the fixed axis is removed, and the body is left free of all supports, and again struck at the centre of percussion, the point of the body which was the centre of suspension when it revolves upon a fixed axis, will be the *Centre of Spontaneous Rotation* when it is left free.

Let S, (Fig. 17. Plate CCCLXIII.) be the centre of spontaneous rotation of the body CD, when struck by the body A in the direction AK. If the body CD had been struck at G with the same force, the point S, supposed to be connected with CD by a rigid line GS, would have moved through Ss = Gg, in the same time that the centre of gravity moved from G to g. But since the point S is actually at rest in consequence of the body CD having been struck at A, the same effect is produced upon the point s, as if it had been carried backwards from s to S in that time. Let $k\,n$ be the space described by any particle p placed at k, in virtue of its rotatory motion round *g*; then in the similar triangles *gkn*, *g* S *s*, we have $Ss : kn = gs : gk$, or $Gg : kn = GS : GK$; that is, the velocities of the centre of gravity G, and the particle *k*, are as SG to GK. Now, calling F the moving force applied at K, the accelerating force by which the centre of gravity is moved, will be $\frac{F}{\int p}$; and by Prop. II. p. 623, the accelerating force with which the point K is urged will be $\frac{F \times GK^2}{\int p\, r^2}$. But as the absolute velocities of G and *p*, which we have shewn to be proportional to SG and GK, are as the accelerating forces, we have $SG : GK = \frac{F}{\int p} : \frac{F \times GK^2}{\int p\, r^2}$, and $SG = \frac{\int p\, r^2}{GK \times \int p}$, which is the same value as was given in Prop. IV. for the distance between the centres of oscillation and gravity; and as the centre of oscillation coincides with the centre of percussion, it follows, that the distance between the centre of percussion and that of gravity is the same as the distance between the centre of spontaneous rotation and that of percussion. Consequently, the distance of the centre of spontaneous rotation from the point K, where the force F is impressed, namely the distance SK, is equal to the distance of the centre of percussion from it, supposing K to be the point of suspension.

Cor. 1. As the value of F does not enter into the expression of SG, it follows that the position of the centre of spontaneous rotation is independent of the momentum of the body A.

Cor. 2. As the distance SG is invariable, and as the point S is carried forward in a direction S *s*, parallel to G *g*, while it revolves at the same time round G, it follows, from the generation of the cycloid, that the centre of spontaneous rotation will describe the common cycloid during every revolution of the body.

Prop. VIII.

If a body revolves round a *first* axis passing through its centre of gravity, while this first axis is carried round a *second* axis, also passing through the centre of gravity, these two motions will constitute a motion of every particle of the body round a third axis lying in the plane of the *first* and *second* axis, and inclined to them at angles whose sines are inversely as the angular velocities round them; and the angular velocity round this third axis is to the angular velocity round one of the primitive axes, as the sine of the inclination of the two primitive axes is to the sine of the inclination of the third axis to the other primitive axis.

Let the body AB *a b*, (Fig. 4. Plate CCCLXIV.) revolve round an axis AG *a*, with the angular velocity *a*, while the axis AG is carried round a second axis BG *b*, with the angular velocity *b*, then if we take GD to GE, as *a* is to *b*, and joining DE, draw CG *c*, through G, parallel to DE, every particle of the body will be in a state of rotation round a third axis CG *c*, which of course lies in the plane of the other two, and the angular velocities *a*, *b*, *c*, are to one another as the lines DE, GD, and GE.

Let P be any particle of the body, and let a spherical surface be conceived to be described round G, and passing through P, then it is manifest that, if PR is perpendicular to the plane of the figure, it will be the common section of the circle of rotation IP *i* round the axis AG *a*, and the circle of rotation K P *k* round the second axis BG *b*. From P draw PF and P *o*, which will be the radii of the circles of rotation IP *i*, KP *k*, and draw PM and PN, touching the same circles in P. These tangents lie in a plane MPN, which touches the sphere in P, and cuts the plane of the axis in a line MN, to which GR, a line drawn from the centre of the sphere through R, is perpendicular. Now, if we represent the velocity of the point P round the axis A *a* by P *f*, and its velocity round B *b* by PN, and complete the parallelogram PN *t f*, the diagonal P *t*, lying in the plane MPN, will represent the velocity of the point P as resulting from these two rotations. Let the parallelograms PN *t f* be projected orthographically into RNTF, on the plane of the axis, by letting fall the perpendiculars *f h* and *t* T, and having drawn the diagonal RT, it is obvious that because PR is perpendicular to the plane of the two axes, the plane PR *t* T is also perpendicular to that plane; consequently the resulting motion P *t* is in the plane of a circle of revolution round some axis situated in the plane of the other two. Produce TR, and draw GHC perpendicular to it, and let L P *l* be a circle of rotation round CG *c* as an axis, and PH a radius of it. The line P *t* will therefore be a tangent to this circle at the point P, and consequently perpendicular to PH, and will, when produced, meet RP in some point Q of the line MN. The particle P is in a state of rotation round the axis CG *c*, and its velocity is to the velocities about the two primitive axes AG *a*, BG *b*, as P *t* is to P *f* or PN. Since the tangent PN is at right angles to the radius OP, and PR at right angles to ON, the triangles PRN, OPN, are similar, and therefore we have $RN = \frac{PR \times PN}{OP}$; but the velocity of P round the axis BG *b* is $OP \times B$, consequently $RN = \frac{PR \times OP \times b}{OP} = PR \times b$. For the same reason we obtain $RF = PR \times a$, and therefore $RF : RN = a : b = GD : DE$; but as the sides are to one another as the sines of the opposite angles, we have sin.∤NRT : sin. NTR = sin. GED : sin. GDE. But because NR is at right angles to EG, and NT perpendicular to DG, we have RNT = EGD. Consequently TR is perpendicular to ED, and C *c* is parallel to ED, and the particle P has a rotatory motion round an axis parallel to ED. Hence, since RN, RF, RT, are as the velocities *b*, *a*, *c*, round these different axes, and are to one another as EG, DG, DE, it follows that the velocities *c*, *a*, and *b*, round the three axes, are to one another as ED, GD, and GE.

The preceding important theorem is given by Frisi in his *Cosmographia.*

CHAP. VI.

ON TORSION.

Def. When a metallic wire, or any other body, is twisted, the force with which it untwists itself is called the *Force of Torsion.* Let *a b*, for example, (Plate CCCLXIV. Fig. 5.) be a metallic wire held firmly by the pincers *c*, by means of the screw *s*, and let a cylindrical body P be suspended vertically by the wire *a b*, firmly fixed to it, so that the wire passes through the axis of the cylinder. Let an index P *o* be fixed to the lower end of the cylinder, for the purpose of pointing out the degrees on a graduated circle concentric with the circumference of the cylinder. If, when the whole is at rest, we turn the cylinder P round its axis, so that the index P *o* may describe the arch *o n*, the wire *a b* will be twisted by this operation, and if left to itself, the tendency of the particles to recover their former situation will cause it to untwist; the index P *o* will return, and will oscillate backwards and forwards like a pendulum, till it is brought to rest by the resistance of the air, and the imperfect elasticity of the metallic wire. The angle *o* P *n*, through which the index had moved, or through which the wire had been twisted, is called the *Angle of Torsion*, and the force by which the oscillations are produced, the *Force of Torsion*.

If the wire possessed perfect elasticity, and was twisted in a perfect vacuum, the cylinder would oscillate for ever, and the oscillations would all be of the same length. By observing, therefore, the diminution of the amplitude of the oscillation, and abstracting the effect produced by the resistance of the air, we may determine the laws according to which the elastic force of torsion is altered.

M. Coulomb was the first person who conceived the happy idea of employing the resistance of torsion to measure very small forces, which require to be ascertained with a degree of accuracy that cannot be obtained by ordinary means. In our articles HYDRODYNAMICS, ELECTRICITY, and MAGNETISM, we have already shewn at great length the practical application of this method, which Coulomb himself had made for ascertaining the laws of the resistance of fluids in very slow motions, and for determining the laws of electrical and magnetical action. We shall therefore proceed to investigate, after the same eminent author, the mechanical laws of the force of torsion, on the supposition that the forces of torsion are proportional to the angle of torsion, a supposition which is perfectly conformable to experiment when the amplitude of the angle of torsion is not too great.

Let PP, (Plate CCCLXIV. Fig. 6.) be a horizontal section of the cylinder P, and let all the elements of this cylinder be projected on the circular section in π, π, π, &c. Let ACM, the primitive angle of torsion, be called A, and after a certain time t, let the amplitude of the oscillations have diminished so as to have become $=$AC m. The diminution of the amplitude will therefore be MC m, which we may call S, so that we shall have AC $m = \mathrm{A} - \mathrm{S}$. As the force of torsion is assumed to be proportional to the angle of torsion, the momentum of this force may be represented by $n \times \overline{\mathrm{A} - \mathrm{S}}$, n being a constant co-efficient depending on the nature, the length, and the thickness of the metallic wire. Hence, if we call v the velocity of any point π, at the end of the time t, when the angle of torsion is AC m, we shall have, by the principles of Dynamics,

$$n \times \overline{\mathrm{A} - \mathrm{S}} \times \dot{t} = \int \pi r \dot{v},$$

where r is $= \mathrm{C}\pi$, the distance of the point π from the axis of rotation C.

But if the radius CA′ of the cylinder is called a, and if u represent the velocity of the point A′ of the circumference of the cylinder at the end of the time t, we have $v : u = r : a$, and $v = \frac{r\,u}{a}$. By taking the fluxion, therefore, of this expression of v, and substituting it in place of $\dot{}$ in the above formula, we get

$$n \times \overline{\mathrm{A} - \mathrm{S}} \times \dot{t} = \dot{u} \int \frac{\pi r^2}{a}$$

and as $\dot{t} = \frac{a\,\dot{\mathrm{S}}}{u}$, we have

$$n \times \overline{\mathrm{A} - \mathrm{S}} \times \frac{a\,\dot{\mathrm{S}}}{u} = \dot{u} \int \frac{\pi r^2}{a},$$

the fluent of which is

$$n \times \overline{2\mathrm{AS} - \mathrm{S}^2} = u^2 \int \frac{\pi r^2}{a^2}.$$

Extracting the square root of both sides of the equation, we have

$$\sqrt{n} \times \sqrt{2\mathrm{AS} - \mathrm{S}^2} = u \times \left(\int \frac{\pi r^2}{a^2} \right)^{\frac{1}{2}}.$$

If we should multiply both sides by $\frac{a\,\dot{\mathrm{S}}}{u}$, and divide by $\sqrt{n} \times \sqrt{2\mathrm{AS} - \mathrm{S}^2}$, the equation will become

$$\frac{a\,\dot{\mathrm{S}}}{u} = \frac{\frac{a\,\mathrm{S}}{u} \times u \times \left(\int \frac{\pi r^2}{a^2} \right)^{\frac{1}{2}}}{\sqrt{n} \times \sqrt{2\,\mathrm{AS} - \mathrm{S}^2}} = \frac{a\,\dot{\mathrm{S}} \times \frac{1}{a} \times \left(\int \pi r^2 \right)^{\frac{1}{2}}}{\sqrt{n} \times \sqrt{2\,\mathrm{AS} - \mathrm{S}^2}}$$

$$= \frac{\dot{\mathrm{S}} \times \left(\int \pi r^2 \right)^{\frac{1}{2}}}{\sqrt{n} \times \sqrt{2\,\mathrm{AS} - \mathrm{S}^2}}.$$

Consequently, since $\dot{t} = \frac{a\,\dot{\mathrm{S}}}{u}$ we obtain

$$\dot{t} = \frac{\dot{\mathrm{S}} \times \left(\int \pi r^2 \right)^{\frac{1}{2}}}{\sqrt{n} \times \sqrt{2\mathrm{AS} - \mathrm{S}^2}}, \text{ or}$$

$$\dot{t} = \frac{\dot{\mathrm{S}}}{\sqrt{2\mathrm{AS} - \mathrm{S}^2}} \times \left(\int \frac{\pi r^2}{n} \right)^{\frac{1}{2}}.$$

But $= \frac{\dot{\mathrm{S}}}{\sqrt{2\mathrm{AS} - \mathrm{S}^2}}$ represents an angle, whose radius is A, and versed sine S, which arch vanishes when $\mathrm{S} = 0$, and which becomes equal to 90° when $\mathrm{S} = \mathrm{A}$ Therefore the time of a complete oscillation will be

$$\mathrm{T} = \left(\int \frac{p\,r^2}{n} \right)^{\frac{1}{2}} \times 180^\circ.$$

In order to compare the force of torsion with the force of gravity in a pendulum, we must recollect that the time of a complete oscillation of a pendulum is

$$\mathrm{T} = \left(\frac{l}{g} \right)^{\frac{1}{2}} 180^\circ,$$

where l is its length, and g the force of gravity. Therefore, since the time in which the cylinder oscillates must be equal to the time in which the pendulum oscillates, we have

$$\left(\int \frac{p\,r^2}{n} \right)^{\frac{1}{2}} 180^\circ = \left(\frac{l}{g} \right)^{\frac{1}{2}} \times 180^\circ.$$

Dividing therefore by 180°, and squaring both sides of the equation, we obtain

$$\left(\int \frac{p\,r^2}{n} \right) = \frac{l}{g}.$$

From this formula, we may easily obtain the value of n after experiment, since the dimensions of the cylinder or of the weight are given, as well as the time of an oscillation, which determines the value of λ.

If it were required to find a weight Q, which, acting at the extremity of a lever L, would have a momentum equal to the momentum of the force of torsion when the angle of torsion is A — S, we must make $Q \times L = n \times A - S$.

We must therefore find for a cylinder the value of $\int \pi r^2$, or the sum of all the particles multiplied by the squares of their distances from the axis. Now, if we make $\phi = 6.28318$, the ratio of the circumference of a circle to its radius, $a =$ radius of the cylinder, $\lambda =$ its length, $\delta =$ its density; then we shall have for the area of its base $\frac{a^2 \phi}{2}$, which multipled by λ gives the solid content of the cylinder $= \frac{a^2 \phi \lambda}{2}$, and this multiplied by δ gives $\frac{a^2 \phi \lambda \delta}{2}$ for the sum of all its particles. But as this is to be multiplied by the sum of the squares of all the distances of the particles from the centre C, we shall have $\int \delta r^2 = \frac{a^4 \phi^2 \lambda \delta}{4}$. But the number of particles in the cylinder, or the mass μ of the cylinder, is $\frac{a^2 \phi \lambda \delta}{2}$, therefore substituting μ, instead of this value of it in the preceding equation, we have $\int p\, r^2 = \frac{\mu a^2}{2}$, and, dividing both sides by a, we have $\frac{\int p r^2}{n} = \frac{\mu a^2}{2n}$, and, extracting the square root, and multiplying by 180°, it becomes

$$\left(\frac{\int p\, r^2}{n}\right)^{\frac{1}{2}} \times 180^\circ = \left(\frac{a^2}{2n}\right)^{\frac{1}{2}} \times 180^\circ. \text{ Therefore}$$

$$T = \left(\frac{\mu a^2}{2n}\right)^{\frac{1}{2}} \times 180, \text{ and since} \int \frac{p\, 2^2}{r} = \frac{l}{g},$$

$\frac{\mu a^2}{2n} = \frac{l}{g}$, and by reduction $n = \frac{g \mu a^2}{2l}$. But $g \mu$ is the weight W of the cylinder; therefore, by substituting W instead of $g \mu$, we obtain $n = \frac{P a^2}{2l}$, a very simple formula for determining the value of n from experiments.

In the preceding investigation we have supposed what is conformable to experiment, that the force of torsion is proportional to the angle of torsion, which gives us $n \times \overline{A - S}$ for the momentum of that force. Let us now suppose that this momentum is altered by any quantity R, then the momentum of the force of torsion will become $n \times \overline{A - S} - R$, and the general equation will assume this form,

$$n \times \overline{A - S} - R \times \dot{t} = \dot{u} \int \frac{p\, r^2}{a};$$

and by substituting in place of $\dot{t}$ its value $\frac{a \dot{S}}{u}$, and taking the fluent, we have

$$\overline{n \times 2AS - S^2} - 2 \int R\dot{S} = u^2 \int \frac{\delta r^2}{a^2}.$$

Now in order to find the value of T, or a complete oscillation, we must divide the oscillation into two parts, the first from B to A, where the force of torsion accelerates the velocity u, while the retarding force, arising from the resistance of the air and the imperfection of elasticity, diminishes the velocity u; and the second from A to B′, where the force of torsion, as well as the other forces, concur in diminishing u, or retarding the motion.

Ex. 1. If $R = s \times \overline{A - S}|^{\nu}$, we shall have for the state of motion in the first portion MA,

$$n \times \overline{2AS - S^2} + \frac{2 s \times \overline{A - S}|^{\nu+1}}{\nu+1} - \frac{2 s A^{\nu+1}}{\nu+1} = u^2 \int \frac{p r^2}{a^2}.$$

Hence, when the angle of torsion is nothing, or $A - S = 0$, we have

$$n A^2 - \frac{2 s A^{\nu+1}}{\nu+1} = UU \int \frac{p\, r^2}{a^2},$$

which dividing by $\int \frac{p\, r^2}{a^2}$, becomes

$$U^2 = \frac{n A^2 - \frac{2 s A^{\nu+1}}{\nu+1}}{\int \frac{p\, r^2}{a^2}}.$$

Let us now consider the other part of the motion from A to M′, and suppose the angle AC $b' = S'$, we shall find, by calling U the velocity of the point A,

$$\frac{n S'^2}{2} + \frac{s S'^{\nu+1}}{\nu+1} = \frac{U^2 - u^2}{2} \times \int \frac{p\, r^2}{a^2}.$$

Then, by substituting instead of U its value as lately found, and taking the fluents, we shall have, when the velocity vanishes, or when the oscillation is finished,

$$A - S' = \frac{2 s}{n \times \overline{\nu+2}} \times \frac{A^{\nu+1} + S'^{\nu+2}}{A + S'};$$

and if the retarding forces are such, that at each oscillation the amplitude is a little diminished, we shall have for the approximate value of A — S′

$$A - S' = \frac{2 s A^{\nu}}{n \times \overline{\nu+1}};$$

and if the angle A—S′ is so small that it may be treated as a common fluxional quantity, we shall then have for any number N of oscillations

$$N \times \frac{2 m}{n \times \overline{\nu+1}} = \frac{1}{\nu-1} \times \left(\frac{1}{S^{\nu-1}} - \frac{1}{A^{\nu-1}}\right.$$

where S represents the angle to which A becomes equal after any number of oscillations N. Hence we obtain

$$S = \frac{1}{\left(N \times \frac{2 s \times \nu - 1}{n \times \nu + 1} + \frac{1}{A^{\nu-1}}\right) \times \frac{1}{\nu - 1}},$$

which determines the value of S after any number of oscillations N.

Ex. 2. If $R = s \times \overline{A - S}|^{\nu} + s \times \overline{A - S}|^{\nu'}$, s' and ν' being different values of s and ν, we shall obtain, by following the mode of investigation in the last example,

$$n\times\overline{A-S}=\frac{2s}{\nu+1}\times\frac{A^{\nu+1}+S^{\nu+1}}{A+S}+\frac{2s'}{\nu'+1}\times\frac{A^{\nu'+1}+S^{\nu'+1}}{A+S};$$

and if the retarding force is much less than the force of torsion, we shall have for an approximate value of $n\times\overline{A-S}$

$$n\times\overline{A-S}=\frac{2sA^{\nu}}{\nu+1}+\frac{2s'A^{\nu'}}{\nu'+1}$$

Ex. 3. In general, if $S=s\times\overline{A-S}|^{\nu}+s'\times\overline{A-S}|^{\nu'}+s''+\overline{A-S}|^{\nu''}+s'''\times\overline{A-S}|^{\nu'''}$, &c. we shall always have for an oscillation when S is smaller than the force of torsion,

$$n\times\overline{A-S}=\frac{2sA^{\nu}}{\nu+1}+\frac{2s'A^{\nu'}}{\nu'+1}+\frac{2s''A^{\nu''}}{\nu''+1}+\frac{2s'''A^{\nu'''}}{\nu'''+1}\text{ \&c.}$$

Having thus given, after Coulomb, the mode of deducing formulæ for the oscillatory motion of the cylinder, we shall now give an account of the results of his experiments for determining the laws of the force of torsion.

These experiments were made with three harpsichord wires of iron, and three brass wires corresponding to the iron wires in their number, and very nearly in their size. The following Table will shew the nature of the wires employed:—

Nature of the wires.	Number of the wires	Number of grains contained in a length of six feet	Weight requisite to break the wires.	
			lbs.	oz.
Iron wires	No. 12	5	3	0
	7	14	10	0
	1	56	33	0
Brass wires	12	5	2	3
	7	18.5	14	0
	1	66	22	0

These wires were fixed successively in the torsion balance shewn in Plate CCCLXIV. Fig. 5. and suspended cylinders of different weights, all of which had a diameter of 19 lines. The various circumstances and results of the experiments are shewn in the following Table:

Nature of the wires	Number of the wires.	Length of the wires in inches.	Weight of the suspended cylinder in pounds.	Limit of the centre of torsion for vibrations perfectly isochronous.	Time in which 20 isochronous oscillations were performed
Iron	No. 12	9	0.5	180	120″
	12	9	2.0	180	242
	7	9	0.5	180	42
	7	9	2.0	180	85
	1	9	2.0	45	23
Brass	12	9	0.5	360	220
	12	9	2.0	360	442
	7	9	0.5	360	57
	7	9	2.0	360	110
	7	36	2.0	1080	222
	1	9	2.0	50	32

In the preceding experiments, the angle of torsion is always so small, that the particles of the wire return to their primitive state. If the angle of torsion, however, exceeds that in the Table, the centre of the reaction of torsion will be displaced.

As in all the preceding experiments the 20 oscillations were sensibly isochronous, we may regard it as a fundamental law, *that in all metallic wires, when the angles of torsion are not very great, the force of the reaction of torsion is sensibly proportional to the angle of torsion.* Hence it follows, that the formulæ already deduced from this supposition may be applied to these experiments.

Since by these formulæ we had $T=\left(\frac{\mu a^2}{2n}\right)^{\frac{1}{2}}180°$, and since in all the preceding experiments the cylinders of half a pound and of two pounds weight had the same diameter, it follows, that n ought to be always proportional to $\frac{\mu}{T^2}$.

If we compare the results of the 1st and 2d experiments, of the 3d and 4th, of the 7th and 8th, and of the 9th and 10th, it will be seen, that with the same wire, the weight of two pounds performs its oscillations in double the time employed by a weight of half a pound. Thus 242″, 85″, 442″, and 110″, are nearly double of 120″, 43″, 220″, and 57″. And since $\sqrt{\frac{1}{2}}:\sqrt{2}=.7071:1.4142=1:2$, it follows, that T is proportional to $\sqrt{\mu}$, or *that the durations of the oscillations are as the square roots of the weights.* Hence it appears, that a greater or a less degree of tension in the wire has no sensible effect upon the reaction of the force of torsion. Coulomb however found, from many experiments made with tensions, very great in proportion to the force of the wire, that these tensions diminished a little the force of torsion. The wire, indeed, is obviously elongated as the tension increases, and as its diameter is thus diminished, the direction of its oscillations ought also to be diminished.

In considering how the force of torsion should be influenced by the length of the wire, it is obvious, that in proportion as we increase the length of the wire, we may cause it to allow, in the same proportion, a greater number of revolutions to be given to the cylinder without changing the degree of torsion. Hence, for the same number of revolutions, the force of the reaction of torsion ought to be inversely proportional to the length of the wire. Since $T=\left(\frac{\mu a^2}{2n}\right)^{\frac{1}{2}}180°$, we shall have for the same weight T proportional to $\frac{1}{\sqrt{n}}$, so that if n is in the inverse ratio of the lengths, as the theory announces, T will be as the square roots of the lengths of the wires. By comparing the 10th and 13th experiments, it appears that the lengths of the wires are as 1 to 4 when the times of the oscillations are as 1 : 2; hence it follows, *that the times of the same numbers of oscillations are, when the same wires are stretched by the same weights, as the square root of the lengths of these wires*, as indicated by the theory.

If we suppose the lengths and the tensions of the wires to be equal, while the size of the wires varies, it will be found, *that the times of the oscillations are recipro-*

cally proportional to the weights of the wires. Thus, in the three experiments on the iron wires, with a tension of two pounds, we have the times of the oscillations 242″, 185″ and 23″, when the weights are 5 grains, 14 grains, and 56 grains, but $242 \times 5 = 1210$; $85 \times 14 = 1190$, and $23 \times 56 = 1288$; consequently, since these products are nearly equal, the times are nearly in the reciprocal ratio of the weights.

When the lengths of the wires and their tensions remain the same, *the force of torsion is proportional to the fourth power of the diameter of the wires*, or for the same length, *to the square of their weight.* Calling T and T′ the times of a certain number of oscillations for a wire whose diameters are D, D′, and the weights for the same lengths ϕ, φ', and ν the exponent of the power of D, to which the force of torsion is proportional, then we may suppose $T : T' = D\,\upsilon : D'\,\upsilon = \varphi\frac{\nu}{2} : \varphi'\frac{\nu'}{2}$, from which we obtain $\nu = \frac{2\,(\text{Log. } T - \text{Log. } T')}{\text{Log. } \varphi - \text{Log. } \varphi'}$.

Now, if we compare, by means of this formula, the 2d and 4th experiments, the 2d and 6th, the 8th and 10th, and the 8th and 12th, we shall obtain

$$\nu = -182 \quad \nu = -2.04$$
$$\nu = -195 \quad \nu = -2\,02, \text{ whence}$$

$$T : T' = \frac{1}{D^2} : \frac{1}{D'^2} = \frac{1}{\varphi} : \frac{1}{\phi'}.$$

But we have already seen that n is proportional to $\frac{\mu}{T^2}$, or when the weights are equal to $\frac{1}{T^2}$. Hence it follows, that the force of torsion for wires of the same nature and of the same length, but of different thicknesses, are as the fourth power of the diameter, a result which the theory also gives.

From all these observations, it follows in general, *that the momentum of the force of torsion, for wires of the same metal, is directly in the compound ratio of the angle of torsion, and the fourth power of the diameter, and inversely as the length of the wires.* If l, therefore, is the length of the wire, D its diameter, and B the angle of torsion, the force of torsion will be $\frac{s\,BD^4}{l}$, in which s is a constant co-efficient, depending on the elasticity of each metal, but invariable in wires of the same metal.

In order to determine the effective value of n, we must apply the formula $n = \frac{P\,a^2}{2\,\lambda}$ to the 2d experiment; where $P = 2$lbs. $a = 9\frac{1}{2}$ lines, and $\lambda = 440\frac{1}{2}$ lines, and where 20 oscillations were performed in 242″. The length of a pendulum isochronous with the oscillations of the cylinder, will be $440\frac{1}{2}\left(\frac{242}{20}\right)^2$, consequently

$$n = \frac{2\text{lbs. } (9\frac{1}{2})^2}{2 \times 440\frac{1}{2}\left(\frac{242}{20}\right)^2} = \frac{1 \text{ lb.}}{715};$$

that is, the momentum n B of the iron wire No. 12, having a length of 9 inches, is equal to $\frac{1}{715}$lb. multiplied by the angle of torsion B acting at the extremity of a lever a line in length; or what is the same thing, if we suppose the angle of torsion to be a line long, measured on a circle whose radius is a line, the force of torsion will be equal to $\frac{1}{715}$ of a pound, acting perpendicularly at the extremity of the arm of a lever a line long.

By the same mode of calculation applied to the brass wire No. 12, we shall find $n = \frac{1}{2384.2}$, so that the strength of the iron is to that of the brass wire as $\frac{1}{715} : \frac{1}{2384.2}$, or as 3.34 to 1.

In the preceding investigations, we have considered only that degree of torsion when the twisted wire returns exactly to its primitive state, by a series of decreasing oscillations. In order to determine if the resistance of the air had any share in diminishing the amplitude of the oscillations, Coulomb made the following experiment. The weights used for stretching the wires were 26 lines high and 19 lines in diameter. He then formed out of very thin paper a cylindrical surface of the same diameter as these weights, but with a height of 70 lines. The leaden weight was then made to enter partly into this cylinder of paper, and the oscillations were executed as before without any sensible change. With another paper cylinder, 78 lines high, or three times the height of the leaden cylinder, with which the effects of the resistance of the air ought to have been tripled, no retardation whatever was observed, and therefore he concluded that the diminution of the amplitude of the oscillations arose from the imperfect elasticity of the metal. Coulomb then proceeds to observe the effects which take place when the wires are twisted to a greater degree than in the first experiment, or to such a degree that the particles do not return to their primitive state, but have experienced a permanent change in their position. If the angle of torsion, for example, is 180°, and if the index, instead of returning after the oscillations are completed to the same point, or through the same arc of 180°, has returned only through 170°, then the centre of torsion is said to be displaced, or to have advanced 10°.

In order to observe from the diminution of the oscillations how the elastic force of torsion is altered in the oscillatory motion, when the centre of reaction is not displaced, he used the iron wire No. 1. with a length of six inches and six lines, and supporting a weight of two pounds; then, when the angle of torsion was

Angle of Torsion.	Degrees lost.	
90°	10° were lost in	5½ oscillations.
45	10	10½
22½	10	23
11¼	10	46

When the angle of torsion exceeded 90°, the centre of torsion was displaced, as shown in the following Table:

Angles of torsion given to the wire.	Successive displacement of the centre of torsion.	Total displacement of the centre of torsion.	Angle through which the wire untwists itself
½ circle	8	8	172°
1	50	58	310
2	310	1 circle + 8	410
3	1 circle + 300	2 + 308	420
4	2 + 290	5 + 238	430
5	3 + 280	9 + 158	440
6	4 + 260	14 + 58	460
10	8 + 240	22 + 298	480
14	wire split into two in the direction of its length		

In the preceding Table, the first column contains the angle of torsion through which the index has been turned. The second contains the arch or angle which it wanted of returning to its primitive state, or the displacement of the centre of torsion produced at each successive experiment. The third contains the total displacement, and is found by adding any one displacement in column 2d to all those that precede it. The fourth column contains the angle through which the index has returned, or the effect produced by the reaction of the torsion of the wire, and is found by subtracting the second column from the first.

From the first of these Tables, it appears, that below 45 degrees the alterations are nearly proportional to the amplitudes of the angles of torsion, and that above 45° the alterations augment in a much greater ratio. It appears, from the second Table, that the centre of the reaction of torsion does not begin to be displaced till the angle of torsion is nearly 180°; that this displacement increases in proportion as the thread is twisted; that it is irregular till the angle of torsion is 310°, and that beyond this angle the reaction of torsion remains nearly the same for all angles of torsion. In the fourth experiment, for example, where the angle of torsion is three circles, the displacement is 1 circle + 300°, so that the reaction of torsion has brought back the cylinder only 1 circle+60° or 420°; whereas, in the 7th experiment, the cylinder was brought back only 1 circle + 100° or 460°, after having undergone a total displacement of 14 circles+58°.

The following experiments were made with the iron wire No. 7. whose length was 6 inches 6 lines.

			Oscillations.
When the angle of torsion was	180°	10° were lost in	3½
	90	10	12
	45	10	27
	22½	10	54

The following Table shows the displacement in the centre of torsion.

Angles of torsion given to the wire.	Successive displacement of the centre of torsion	Total displacement.	Angle through which the wire untwists itself.
3	300	300	2 circle + 60°
4	1 circle + 180	2 circle + 120	2 + 180
6	3 + 90	5 + 210	2 + 270
8	5 + 90	10 + 300	2 + 270
12	9 + 40	19 + 340	2 + 320
20	16 + 310	36 + 290	3 + 50
30	26 + 180	63 + 110	3 + 180
50	46 + 20	110 + 130	3 + 340

From all these experiments, M. Coulomb has deduced the following ingenious theory of the elasticity and cohesion of metals.

The integrant particles of all metallic wires have an elasticity which may be considered as perfect; that is, the forces necessary for compressing or dilating these particles are proportional to the dilatation or the compression which they experience. These particles, however, are united together by cohesion, a quantity that is constant and absolutely different from elasticity. In the first degrees of torsion the integrant parts change their form, and are elongated or compressed without any change of place in the points by which they adhere, because the force necessary for producing these first degrees of torsion is less than the force of cohesion. But when the angle of torsion becomes such that the force with which the parts are compressed or dilated is equal to the cohesion which unites these integrant particles, then they ought to separate or slide upon one another. This sliding of the particles takes place in all ductile bodies, but if, by this sliding of the particles upon one another, the body is compressed, the extent of the points of contact, and the extent of the field of elasticity, become greater. As these integrant particles have a determinate figure, the extent of the points of contact cannot augment but to a certain degree, beyond which the body breaks. This view of the difference between the cause of elasticity and cohesion was confirmed by an experiment in which Coulomb could vary the cohesion at pleasure, without altering the elasticity. He brought a wire of copper to the temper of a white heat; and by this means its cohesion was so much reduced that it could scarcely support 12 or 14 pounds, while in its original state, it carried 22 pounds at the instant of rupture. But though the cohesion was thus diminished nearly one half, and though the amplitude of elasticity was diminished nearly in the same proportion, yet, in the extent of elastic reaction which remained, the elasticity was the same at the same angle of torsion as in the untempered wire, as both of them, when stretched by the same weight, performed the same number of oscillations in the same time.

In order to confirm these views, M. Coulomb subjected to experiment plates of steel, by means of the apparatus shewn in Plate CCCLXIV. fig. 7. A plate of steel AB, had one of its extremities A fixed between two plates of iron E, F, by means of the screw VD. The plate was 11 lines wide, half a line thick; and its length from *a* to B, where the weight was suspended, was seven inches. The descent of the extremity B, by the action of the weight P, was measured upon a vertical scale MN.

When the plate of steel was brought to a white heat, and tempered very hard, it was loaded with different weights, as in the following Table.

Magnitude of the weight P.	Descent of the extremity B.
½ pound	8 lines
1	15½
1½	23+

The same plate was then heated till it received a violet colour, and returned to the state of an excellent spring, and when placed in the apparatus with the very same weight, its extremity descended the very same quantities.

It was at last brought to a white heat, and allowed to cool very slowly, and the same effects were produced by the same weights as before.

In these three experiments, the first degrees of the elastic forces suffered no change. The same weights produced the same degree of flexure, and by removing them the plate returned to its horizontal position.

In order to find the strength of the plates in these different states, Coulomb formed three plates out of a piece of English steel exactly similar to those above mentioned, and having tempered one of them at a white heat, another when it had a violet colour, while a third was allowed to cool slowly from a red head, he placed these plates successively in the apparatus, and applied weights at the point *d*, 2½ inches from *a*. The *first* plate broke with *six pounds*; but to whatever angle it was bent below that at which it broke, it always resumed its primitive horizontal state; the *second* broke with *eighteen pounds*; it bent to the point of rupture into an angle nearly proportional to the force applied to it. The third plate bent with a force of *five or six pounds* proportionally to this force, and into an angle exactly equal, under the same force, to that into which it was bent when in its two former states. But in afterwards applying the force perpendicularly to the direction of the plate, in order to preserve the same length of lever, a force of seven pounds was sufficient to bend it to all angles, and when the weight was removed, it returned only by a quantity through which it had been originally bent by a force of six pounds, so that the angle of the reaction of flexion was changed from any angle into which it was bent, with a force greater than seven pounds.

These last experiments conduct us to the same result as the preceding ones. It is obvious, that in order to have an idea of what happens in the flexion of metals, we must distinguish the elastic force of the integrant particles from the force of cohesion, which unites these particles together. The elastic force depends, as we have seen, on the compression and dilatation which these integrant parts experience, and is always proportional to the compressing and dilating forces. These integrant particles are not altered either by tempering or annealing, since in these different states the elasticity is the same under the same degrees of flexion. But the same particles are united only by a certain degree of cohesion, which depends probably on their figure, and on the respective portions of different fluids with which their pores are filled, which varies according to the state of temper and annealing. In very hard-tempered steel, and in good springs, the particles cannot either slide upon one another, or experience the least displacement, without the body breaking; but in ductile bodies, or annealed metals, these particles may slide upon one another, and be displaced, without the cohesion being sensibly altered.

What has now been said respecting metals may be applied to all bodies. Their integrant particles have always a perfect elasticity, but the bodies are hard, soft, or fluid, according to the cohesion of these particles. If in hard bodies they can slide upon one another without their distance being sensibly altered, the body will be ductile or malleable; but if they cannot slide upon one another without their distance being sensibly altered, the body will break, when the force with which it is compressed or dilated is equal to the cohesion.

CHAP. VII.

ON THE MAXIMUM EFFECT OF MACHINES.

When any power is made to act upon a given resistance, by the intervention either of a simple or a compound machine, an equilibrium will take place when the velocity of the power is to the velocity of the resistance as the weight is to the power. In this state of things, however, the machine must be actually at rest, and therefore incapable of performing any work. If we can increase the power, the machine will move with more and more velocity, and will have its motion gradually accelerated as long as the power exceeds the resistance. But if from any cause the power should begin to diminish, or if the resistance should increase, or if both these changes on the state of the machine should take place at the same time, the acceleration of the machine will diminish, and it will at last arrive at a state of uniform motion. Now, this increase of resistance may arise in many cases from an increase of friction, which often (though not always) accompanies an augmentation of velocity; or it may arise from the resistance of the air, which must necessarily increase with the velocity; and therefore all machines are found soon to attain a state of uniform motion. When an undershot wheel is driven by the impulse of water, the uniformity of motion to which it arrives, arises principally from the diminution of the power which in this case accompanies an increase of velocity. When the mass of fluid strikes one of the float-boards at rest, the impulse is then a maximum. When the float-board is in motion, it withdraws itself, as it were, from the action of the power, and therefore its mechanical effect will diminish as the velocity increases, and if it were possible that the velocity of the wheel should become equal to that of the fluid, the float-board would not be struck at all by the moving water. Hence it follows, that the power itself diminishes by an increase of velocity, and therefore that from this cause alone machines in general would soon acquire a motion sensibly uniform. This effect will be more easily understood, if we suppose an axle to be put in motion by two currents of water, moving with different velocities and driving two wheels, one of which is placed at each extremity of the axles. When the wheels have begun to move, by the joint action of these falls of water, its motion will at first be slow, and each fall of water will perform its part in giving motion to the axle; but if the greater fall is capable, by the continuance of its action, of giving its wheel a velocity either equal to, or greater than the velocity of the smaller fall, then it is manifest that the smaller fall ceases to impel its wheel, and that the whole effect is produced by the action of the greater fall. Hence it is easy to understand from this statement, not only why a diminution of the impelling power accompanies an increase of velocity, but why there is a certain velocity of the machine, which is necessary before we can gain all the useful effect which we wish to have from the powers which we employ.

In order to illustrate this in the case of a real machine, let us suppose that the power of a man is to be employed in raising a load, by means of the machine, or walking crane, shewn in Plate CCCLXIV. Fig. 8

This machine consists of a large wheel AB, placed upon an axis CD, round which is coiled a rope, to the lower extremity of which a weight or resistance R is attached; the man walks upon the interior of the wheel, and by his weight gives it a rotatory motion, and therefore coils the rope round CD, and elevates the weight R. Let us suppose that the drum or wheel is so constructed, like the fusee of a watch, that the man can walk to different distances from the axis; and let P be the power or weight of the man, R the weight to be raised, and y the radius of the axle; then since $R : P = y : \frac{Py}{R}$, the distance from the centre of the wheel, at which the man must place himself, in order to be in equilibrio with the resistance R. But as the machine must be moved, and the weight raised, the man must go to a greater distance from the axis than $\frac{Py}{R}$; the motion of the machine will therefore accelerate, and the acceleration would increase if he moved to a greater and greater distance from the centre of the wheel. Hence it is obvious, that as the acceleration increases, the man must walk with greater and greater velocity; but there is an obvious limit to this, for he would soon be fatigued by the rapid walking, and would therefore be rendered unfit to continue his work. He must therefore return to that distance from the axis, where the wheel has such a velocity that he can continue to move with that velocity during the period that his work is to last. There is therefore a particular velocity with which the man must walk, in order to perform the greatest quantity of work; and it would be easy to find this velocity, if we knew the law according to which his force diminished, as his velocity increased. We may suppose, however, that his force diminishes in the same ratio as his velocity increases.

Let P represent the force which a man at rest can exert during a given time against a weight or load. This force will obviously be greater than any which he could exert when in motion; for a part of his strength is expended in putting himself in motion, and in continuing it. Let V be the velocity at which he would lose the power of exerting any force, then if he moves with any velocity v less than V, he will obviously lose a part of his maximum force P, and the part lost will be found from the hypothesis, by the analogy $V : v = P : \frac{Pv}{V}$. The real force, therefore, which he exerts against the weight, will be $P - \frac{Pv}{V}$, or, by separating its two factors, $P\left(1 - \frac{v}{V}\right)$. Now, if x is the length of lever by which this force acts, R the resistance or weight raised, y the radius of the axle, and U the velocity of the weight; then when the machine has obtained a uniform motion, we shall have $P\left(1 - \frac{v}{V}\right)x = R\,y$; but since $x : y = v : U$, we have by substitution $P\left(1 - \frac{v}{V}\right)v = R \times U$, which is the equation to a circle, and this effect will be a maximum when $v = \frac{V}{2}$; and substituting this value of v, we shall have $R \times U = \frac{PV}{4}$; that is, the man will do most work when he moves with half of his greatest velocity, and in that case the greatest effect will be $\frac{PV}{4}$.

It appears, however, from direct experiments, that the force of a man diminishes as the square of his velocity increases; and therefore we must take $V^2 : v^2 = P : \frac{Pv^2}{V^2}$, and then we shall have the formula

$$P\left(1 - \frac{v}{V}\right)^2 v = RU,$$

an equation to a parabola, which will be a maximum when $v = \frac{V}{3}$, and $RU = \frac{4P}{9}$; that is, the force of a man, or any other animal, will be a maximum when they move with a velocity equal to one-third of their greatest velocity, and when the load is $\frac{4}{9}$ths of the greatest load which they are able to put in motion.

Having thus considered the maximum effect of living agents, we shall proceed to the subject of machines, and shall take the case of a wheel and axle, as almost all other machines may be considered as reduced to this.

Def. 1. The powers by which a machine is put in motion, and by which that motion is kept up, are called the *first movers*, or *moving powers;* and in *general mechanical agents*, and when various moving powers are applied to the same machines, the resultant of them, or the equivalent force, is called the *moving force.*

The first movers of machinery are, in general, the force of men and animals, the force of steam, the force of wind, the force of moving water, the weight of water, the reaction of water, the descent of a weight, the elasticity of a spring, &c. If a machine is driven by two powers acting in two different directions, we must then find their resultant, and consider the machine as driven by the resulting force.

Def. 2. The powers which oppose the production of motion in a machine, and its continuance, are called the *resistances*: and the resultant of all the resisting forces is called the *resistance.*

The work to be performed is, in general, the principal resistance to be overcome; but, in addition to this, we must consider the resistance of friction, and the resistance arising from the inertia of all the parts of the machinery; for a certain portion of the moving power is necessarily wasted in overcoming these obstacles to motion.

Def. 3. The *impelled point* of a machine is that point to which the moving power is applied, or rather that point at which the moving force is supposed to act, when this moving force is the resultant of various powers differently applied. The *working point* of a machine is that point at which the resistance is overcome, or that point to which the resultant of all the resisting forces is supposed to act.

Def. 4. The *work performed*, or the *effect* of a machine, is equal to the resistance multiplied by the velocity of the working point.

Def. 5. The momentum of impulse is equal to the moving force multiplied by the velocity of the impelled point.

In proceeding to investigate general expressions for the ratio of the velocities of the impelled and working points of machines, when their performance is a maximum, let

x=the radius of the wheel to which the power is applied; or, which is the same thing, the velocity of the impelled point of the machine.

y=the radius of the axle to which the resistance is applied, or the velocity of the working point of the machine.

P=the moving force applied at the impelled point.

R=the resistance arising solely from the work to be performed.

m=the inertia of the moving power P, or the quantity of matter to which that power must communicate the velocity of the impelled point.

n=the inertia of the resistance, or the quantity of matter which it must move with the velocity of the working point before any work can be performed.

f=the quantity of matter, which, if placed at the working point, would create the same resistance as friction.

i=the quantity of matter, which, if placed at the working point, would oppose the same resistance as the *inertia* of all the parts of the machinery.

Since x and y are the radii of the wheel and axle, we shall have by Prop. I. page 605, $x : y = \mathrm{R} : \frac{\mathrm{R}\,y}{x}$, a weight which is equal to that part of the power P which is in equilibrio with the resistance. We have, therefore, $\mathrm{P} - \frac{\mathrm{R}\,y}{x}$ as an expression of the effective force of the power; and as x is the length of lever at which this force is applied, we have $\mathrm{P}\,x - \mathrm{R}\,y$ to represent the force which is employed in giving an angular motion to the machine. The resistance which friction opposes to this force will be $f\,y$; and the momentum of inertia of the machinery will, by Prop. I. p. 622, be $i \times y^2$; the momentum of inertia of the power P will be $m\,x^2$; and the momentum of inertia of the resistance, $n\,y^2$. As the moving force is diminished by the resistance of friction, we shall have $\mathrm{P}\,x - \mathrm{R}\,y - f\,y$ for the moving force; and as the resistance arises from the momentum of inertia of the resistance, the inertia of the power, and the inertia of the machinery, it will be equal to $m\,x^2 + n\,y^2 + i\,y^2$. But as by Prop. I. p. 622, the angular velocity is proportional to the moving force directly, and to the quantity of matter to which it is applied inversely, we have

$$\text{The angular velocity} = \frac{\mathrm{P}\,x - \mathrm{R}\,y - f\,y}{m\,x^2 + n\,y^2 + i\,y^2}.$$

But as the velocities of the impelled and working points are as their distances from the centre of motion, or as x and y, we shall obtain these velocities by multiplying the angular velocity by x and y; and as by Def. 4, the work performed is equal to the resistance multiplied by the velocities of the working point, we shall have

$$\text{Velocity of impelled point} = \frac{\mathrm{P}\,x^2 - \mathrm{R}\,x\,y - f\,x\,y}{m\,x^2 + n\,y^2 + i\,y^2}.$$

$$\text{Velocity of working point} = \frac{\mathrm{P}x\,y - \mathrm{R}\,y^2 - f\,y^2}{m\,x^2 + n\,y^2 + i\,y^2}.$$

$$\text{The work performed} = \frac{\mathrm{R}\mathrm{P}\,x\,y - \mathrm{R}^2 y^2 - \mathrm{R}\,f\,y^2}{m\,x^2 + n\,y^2 + i\,y^2}.$$

In order to obtain absolute measures of the velocities and the work performed, we must consider that $v = \mathrm{F}\,t$, or is $= g\,t\,\mathrm{F}$, F being the accelerating force: and as the accelerating forces are proportional to the velocities generated by them in equal times, the preceding expressions for the velocities of the impelled and working points may be substituted for the accelerating force F in the equation $v = g\,t\,\mathrm{F}$, and we obtain

The absolute velocity of the impelled point

$$= \frac{\mathrm{P}\,x^2 - \mathrm{R}\,x\,y - f\,x\,y}{m\,x^2 + n\,y^2 + i\,y^2} \times g\,t$$

Absolute velocity of the working point

$$= \frac{\mathrm{P}\,x\,y - \mathrm{R}\,y^2 - f\,y^2}{m\,x^2 + n\,y^2 + i\,y^2} \times g\,t.$$

And the work performed

$$= \frac{\mathrm{R}\mathrm{P}\,xy - \mathrm{R}^2\,y^2 - \mathrm{R}\,f\,y^2}{m\,x^2 + n\,y^2 + i\,y} \times g\,t.$$

By considering y as the variable magnitude, and making the fluxion of the last formula $=0$, we shall find that the work performed is a maximum, when

$$y = x\,\frac{\sqrt{m^2(\mathrm{R}+f)^2 + \mathrm{P}^2 m(i+r)} - m(\mathrm{R}+f)}{\mathrm{P}(i+n)}.$$

When R=0, we obtain

$$y = x\,\frac{\sqrt{m^2 f^2 + \mathrm{P}^2 m(i+r)} - m\,f}{\mathrm{P}(i+n)}.$$

This case takes place when the resistance to be overcome exerts a contrary strain on the machine, but consists merely in the inertia of the impelled body; as in driving a millstone, a fly, or in pushing a body along a horizontal plane.

When $f=0$, then $y = x\,\frac{\sqrt{m^2 \mathrm{R}^2 + \mathrm{P}^2 m(i+r)} - m\,\mathrm{R}}{\mathrm{P}(i+n)}$.

This case takes place when the friction is so small that it may be disregarded, which often happens in good wheel work, where the surfaces that touch one another are very small.

When R=0, and $f=0$, we have

$$y = x\sqrt{\frac{\mathrm{P}^2 m(i+n)}{\mathrm{P}^2(i+n)}} = x\sqrt{\frac{m}{i+n}}.$$

This case takes place when the circumstances of the two preceding cases are combined.

When $n=0$, we have

$$y = x\,\frac{\sqrt{m^2(\mathrm{R}+f)^2 + \mathrm{P}^2 m\,i} - (\mathrm{R}+f)}{\mathrm{P}\,i}.$$

This case takes place in the grinding of corn, the sawing of wood, the boring of wooden or iron cylinders, &c. where the quantity of motion communicated to the flour, the saw dust, or the iron filings, is too trifling to be taken into account.

When R=0, $f=0$, and $n=0$, we have $y = x\sqrt{\frac{m}{i}}$.

When $m : n = \mathrm{P} : \mathrm{R}$, we have

$$y = x\,\frac{\sqrt{\mathrm{P}^2(\mathrm{R}+f)^2 + \mathrm{P}^3(i+\mathrm{R})} - \mathrm{P}(\mathrm{R}+f)}{\mathrm{P}(i+\mathrm{R})}.$$

This case takes place when the inertia of the power and the resistance are proportional to their pressure; as when water, minerals, or any other heavy body, is raised by means of water acting by its weight in the buckets of an overshot wheel.

When, in the preceding case, $i = 0$, and $f = 0$, we have

$$y = x\sqrt{\frac{P}{R} + 1} - 1.$$

This case often takes place, and particularly in pulleys; and making $x = 1$, and $R = 1$, we obtain

$$y = \sqrt{P + 1} - 1;$$

and when $P = 1$, and $x = 1$, we have

$$y = \sqrt{\frac{1}{R} + 1} - 1.$$

The preceding formulæ will be found applicable to almost every case which can occur; and the intelligent engineer will have no difficulty in accommodating them to any unforeseen circumstances.

The following table will, in many cases, save the trouble of calculation. It is computed from the formula $y = x\sqrt{\frac{P}{R} + 1} - 1$, x being supposed $= 1$, and $R = 10$.

Table containing the best Proportions between the Velocities of the Impelled and Working Points of a Machine, or between the Levers by which the Power and Resistance act.

Proportional value of the impelling power, or P.	Value of the velocities of the working point, or y, or of the lever by which the resistance acts, that of x being 1.	Proportional value of the impelling power, or P.	Value of the velocities of the working point, or y, or of the lever by which the resistance acts, that of x being 1.
1	0.048809	20	0.732051
2	0.095445	21	0.760682
3	0.140175	22	0.788854
4	0.183216	23	0.816590
5	0.224745	24	0.843900
6	0.264911	25	0.870800
7	0.303841	26	0.897300
8	0.341641	27	0.923500
9	0.378405	28	0.949400
10	0.414214	29	0.974800
11	0.449138	30	1.000000
12	0.483240	40	1.236200
13	0.516575	50	1.449500
14	0.549193	60	1.645700
15	0.581139	70	1.828400
16	0.612451	80	2.000000
17	0.643168	90	2.162300
18	0.673320	100	2.316600
19	0.702938		

In order to understand the method of using the preceding table, let us suppose that we wish to raise *two* cubic feet of water in a second, by means of the power of a stream which affords five cubic feet of water in a second, applied to a wheel and axle, the diameter of the wheel being seven feet. It is required, therefore, to find the diameter which we must give to the axle, in order to obtain a maximum effect. We have obviously $P = 5$, and $R = 2$, and $P = \frac{5}{2}R$; but, in the above table, $R = 10$: hence $P = \frac{5}{2} 10 = 25$. Now, it appears from the table, that when $P = 25$, the diameter of the axle, or y, is 0.8708 when $x = 1$; but as $x = 7$, the diameter of the axle must be $7 \times 0.8708 = 6.0956$.

When a machine is already constructed, the velocities of its impelled and working points are determined; and therefore, in order to obtain from it its maximum effect, we must seek for the best proportion between the power and the resistance, as these are the only circumstances over which we have any control, without altering the machinery.

In order to find the ratio of P to R, which would give a maximum effect, it is requisite only to make R variable in the formula before given; but it often happens, that when R varies, the mass n suffers a considerable change, although there are other cases when the change in n is too inconsiderable to be noticed.

Let us, therefore, first take the case when R alone varies without inducing a change upon n. In this case, the expression of the work performed, viz. $\frac{RPxy - R^2y^2 - Rfy^2}{mx^2 \times ny^2 + iy^2}$ will be a maximum when $R = \frac{Px - fy}{2y}$. But, according to the experiments of Coulomb, the friction is in general equal to $\frac{1}{15}$th of the resisting pressure. Hence we may omit fy, and consider the resistance as $= R + \frac{1}{15}R = \frac{16}{15}R$. Consequently, $\frac{16}{15}R = \frac{Px}{2y}$, and $R = \left(\frac{Px}{2y}\right) \div \frac{16}{15}$. But if we consider the fraction $\frac{16}{15}$ as so near 1, that the substitution of the latter will not greatly affect the result, we shall obtain, by making $P = 1$ and $x = 1$, $R = \frac{1}{2y}$; that is, the resistance should be nearly one-half of the force which would keep the impelling power in equilibrio—a rule which is applicable to many cases where the matter moved by the working point of the machine is inconsiderable.

In those cases where n varies along with R, it will in general vary in the same proportion, and we may therefore represent n by d R, some multiple of R. For the sake of simplicity the friction f may be considered as absorbing a certain portion of the impelling power, which will then be represented by $P - f$; and we may also regard the inertia of the machine, or i, as applied to the impelled in place of the working point; that is, the momentum of inertia may be called $m x^2$. Now, if we make $P - f = 1$, and $x = 1$ in the formula

$$\frac{RPxy - R^2y^2 - Rfy^2}{mx^2 + ny^2 + iy^2},$$

we shall obtain $\frac{Ry - R^2y^2}{m + i + dRy^2}$; and making $m + i = s$, we have $\frac{Ry - R^2 - R^2y^2}{s + dRy^2}$ for the work performed, which will be a maximum when $R = \frac{\sqrt{s^2 + sdy} - s}{dy^2}$.

When $d=1$, then we have $R=\frac{\sqrt{s^2+sy}-s}{y^2}$. This case takes place when the machine is employed in raising a weight, drawing water, &c.

When $i=0$ and $m=P$, then $m+i=s=1$, and

$$R=\frac{\sqrt{y+1}-1}{y^2}.$$

When $x=y$, as in the common pulley, and $y=1$, then

$$R=\frac{\sqrt{1+1}-1}{1}=\sqrt{2}-=0.4142.$$

In order to save the trouble of calculation, we have added the following table, computed from the formula

$$R=\frac{\sqrt{y+i}-1}{y^2}.$$

Table containing the best Proportions between the Power and the Resistance, the inertia of the impelling power being the same with its pressure, and the friction and inertia of the Machine being omitted.

Values of y, or the velocity of the working point, x being equal to 1.	Values of R, or the resistance to be overcome, P being = 1.	Ratio of R to the resistance which would balance P.	Values of y, or the velocity of the working point, x being equal to 1.	Values of R, or the resistance to be overcome, P being = 1.	Ratio of R to the resistance which would balance P.
$\frac{1}{4}$	1.8885	0.4724 to 1	7	0.03731	0.26117 to 1
$\frac{1}{3}$	1.3928	0.4639 ——	8	0.03125	0.25000 ——
$\frac{1}{2}$	0.8986	0.4493 ——	9	0.02669	0.24021 ——
1	0.4142	0.4142 ——	10	0.02317	0.23170 ——
2	0.1830	0.3660 ——	11	0.02037	0.22407 ——
3	0.1111	0.3333 ——	12	0.01809	0.21708 ——
4	0.0772	0.3088 ——	13	0.01622	0.21086 ——
5	0.0580	0.2900 ——	14	0.01466	0.20524 ——
6	0.0457	0.2742 ——	15	0.01333	0.19995 ——

In order to understand the method of using this table, let us suppose that it is required to find the value of the resistance, or the quantity of water which must be put into a bucket to be raised by a wheel and axle, in which the radius of the wheel is 6 feet, and that of the axle 2 feet, and with a power $=8$. Since, in the table, $x=1$, we have $y=\frac{2}{6}=\frac{1}{3}$, which corresponds in the table to 1.3928, the value of R when $P=1$. But, in the present case, $P=8$, consequently $1:8=1.3928:11.1424$, the value of R when $P=8$.

The subject of the maximum effect of machines may be considered in a very simple point of view, if we suppose, what is by no means improbable, that the moving power in machinery observes the same law that has been found to exist with regard to animal force, and also with regard to the force of fluids in motion. Upon this hypothesis, we shall have $R=P\left(1-\frac{v}{V}\right)^2$, and the effect of the machine will be $Rv=Pv\left(1-\frac{v}{V}\right)^2$, which will be a maximum when $\frac{R}{W}=\frac{4}{9}P$, and when $v=\frac{V}{3}$. In these formulæ, P is the load that is sufficient to bring the machine to rest, or prevent it from moving, V is the greatest velocity of the power when no work is done, and v the velocity of the impelled point of the machine. The velocity of the impelled point of a machine will be to the velocity of the working point, when the effect is a maximum, as 9 R to 4 P.

For farther information on the maximum effect of machines, see Euler, *Comment. Petrop.* 1738, p. 67, Prop. 2. Euler, *Mem. Acad. Berl.* 1748, p. 149. *Id. Nov. Comment. Petrop.* tom. iii. 1750, 1751, p. 254, and tom. viii. 1760, 1761, p. 230. Blake, *Phil. Trans.* 1753, p. 1. Lambert, *Nov. Act. Helvet.* 1787, i. p. 75. Lambton, *Asiatic Researches*, vol. vi. p. 137. Robison's *System of Mechanical Philosophy*, vol. ii. p. 204, whose method of investigation we have followed and simplified. Playfair's *Outlines of Natural Philosophy*, vol. i. p. 123. Bridge's *Mechanics*, Part iii. § 16.

CHAP. VIII.

ACCOUNT OF D'ALEMBERT'S PRINCIPLE.

The celebrated principle of D'Alembert, which he has given in the second part of his *Traité de Dynamique*, is a necessary result of the *third* law of motion, or rather it is the most general and correct expression of the equality of action and reaction. Mr. Playfair has given it the very appropriate name of the *principle of the distribution of motion*, as it is the only general method of determining the manner in which motion distributes itself through all the parts of a system to which it is in any manner communicated. This principle may be expressed in the following manner.

Let there be a system of bodies any how connected with one another, whose masses are M, M', M''; let V, V', V'' be the velocities which would be impressed upon them by any forces whatever, if each of the bodies were insulated. But as the bodies of the system are all connected together, the velocities V, V', V'' will be changed both in their magnitude and direction. Let U, U', U'' be the unknown velocities which they will take in directions which are also unknown; and let v, v', v'' be the velocities lost or gained by the bodies, so that U and v are the velocities which compose V'; U and v' the velocities which compose V'; and U'' and v'' the velocities which compose V''; then there will be an equilibrium in the system between the quantities of motion lost or gained $M\,v$, $M'v'$, $M''v''$; for if these forces were not in equilibrio, then U, U', U'' could not be the actual velocities, which is contrary to the hypothesis.

This principle holds equally, whether V, V', V'' are finite velocities acquired by moving bodies in a finite time, or are due to forces which act instantaneously upon the bodies; and whether these quantities represent velocities infinitely small, and due to accelerating forces, or whether they are partly finite, or partly infinitely small. M. Poisson, whose mode of announcing this principle, and method of applying it, we shall follow, has given it the following more commodious form.

Instead of the forces $M\,v$, $M'v'$, $M''v''$, which ought to be in equilibrio, we may substitute the forces to which they are equivalent. But the force $M\,v$, for example, is the resultant of MV taken in its direction, and of MU taken in a direction opposite to its own, and the same is true of all the others. The principle of D'Alembert, therefore, may be thus expressed; that there is an equilibrium in the system between the quantities of motion MV, $M'V''$, $M''V''$ impressed on the moving bodies, and the quantities of motion MU, $M'U''$, $M''U''$, which actually take place, each of the last being taken in a direction opposite to its own.

When the principle is expressed in this manner, there is no occasion to consider the velocities lost or gained v, v', v'', and we are enabled at once to establish equations of equilibrium between the given velocities V, V', V'', and the unknown velocities U, U', U'', which the equations are intended to determine.

In order to shew the application of this principle, let it be required to determine the conditions of equilibrium, when two heavy bodies, attached to the extremities of an inextensible thread, are placed on two inclined planes of the same height. Let

M=mass of the body placed upon the first inclined plane.
M'=mass of the body placed upon the second inclined plane.
h =common height of the two planes.
l =length of the first.
l' =length of the second.
g =the force of gravity.

The accelerating force which acts upon M, will be the force of gravity decomposed according to the first plane, which will be $\frac{g\,h}{l}$; and the accelerating force which acts upon M', will, in like manner, be $\frac{g\,h}{l'}$. Now, let t be the time elapsed from the beginning of the motion, V the velocity of M, and V' the velocity of M', and let these velocities be considered as positive or negative, according as the bodies descend or ascend. During the instant $\dot{t}$ these velocities will be augmented by $\dot{V}$ and $\dot{V}'$; but during the same instant, the accelerating forces would impress upon the bodies supposed to be free, the positive velocities $\frac{g\,h}{l} \times \dot{t}$, and $\frac{g\,h}{l'} \times \dot{t}$. Hence, as the bodies are connected together, the body M loses the velocity $\frac{g\,h}{l} \times \dot{t} \times \dot{v}$, and the body M' the velocity $\frac{g\,h}{l'} \times \dot{t} - \dot{v}'$ in the instant $\dot{t}$. But by the principle of D'Alembert, the two quantities of motion corresponding to the velocities thus lost must be in equilibrium. By multiplying these velocities, therefore, by the masses, and making them equal to one another, as they are applied in opposite directions at the ends of an inextensible thread, we obtain

$$M\left(\frac{g\,h}{l} \times \dot{t} - \dot{v}\right) = M'\left(\frac{g\,h}{l'} \times \dot{t} - \dot{v}'\right)$$

Now as the two bodies are connected by an inexstensible thread, they must always move with the same velocity, and the one must ascend when the other descends. Hence $+v = -v$, and $v'+v=0$, and $\dot{v}' = -\dot{v}$. By substituting this value of $\dot{v}'$ in the above equation, and reducing, we obtain

$$\dot{v} = \frac{(M\,l' - M'l)h}{(M+M')\,l\,l'} + g\,\dot{t}, \text{ and}$$

$$v = \frac{(M\,l' - M'l)\,h}{(M+M')\,l\,l'} \times g\,t + a;$$

where a is a constant arbitrary quantity, which represents the initial velocity.

Let the variable distance of the mass M from any fixed point, as, for example, from the common summit of the planes, be called x, then we shall have $v = \frac{\dot{x}}{\dot{t}}$ and $\dot{x} = v\,\dot{t}$. If we now substitute in this equation the above value of v, and take the fluent, we shall obtain

$$x = \frac{(M\,l' - M'l)\,h}{(M+M')\,l\,l'} \times \frac{g\,t^2}{2} + a\,t + b,$$

b being still a constant arbitrary quantity equal to the value of x, which answers to the origin of the motion.

Upon examining the preceding values of v and x, it is manifest that the motion of M is analogous to that of a heavy body, when its gravity is diminished in the ratio of $(M\,l' - M'l)\,h$ to $M+M')\,l\,l'$. The motion of M' will be the very same in an opposite direction as that of M. When the initial velocity a is nothing, and when we have at the same time $M\,l' = M'l$, the velocities of the two are nothing, and they are in equilibrio. The condition of equilibrium therefore is, that the masses M and M' of the bodies are in the ratio of the lengths l, l' of the inclined planes upon which they rest, a result which is also obtained by the ordinary methods.

These formulæ contain the theory of Atwood's machine, as we shall have occasion to see in a future part of this article.

The following simple example of the application of D'Alembert's principle to the determination of the action of machines working with a variable velocity, has been given by Mr. Playfair.

Let A and B be two given weights applied to the ends of the arms of a lever, of which the lengths are a and b, and let $A \times a$ be greater than $B \times b$ so that A may preponderate; the space over which B will be raised in one second (g being the velocity which a heavy body acquires in the first second of its descent) is $\frac{(A\,a - B\,b)b}{Aa^2 + B\,b^2} \times \frac{1}{2} g$. Call x the velocity of b then $\frac{a\,x}{b}$ will be the velocity of A. If the bodies were free to fall by their own gravity, the velocity of each would be

g; therefore the velocity lost by A is $g-\frac{a\,x}{b}$, and the velocity gained by B is $g+x$. Now the momenta of these must be equal by D'Alembert's principle; that is, $\mathrm{A}\,a\left(g-\frac{a\,x}{b}\right)=\mathrm{B}\,b\,(g+x)$; and hence x, or the velocity of B, is found, and the half of it is the space over which B is raised in one second.

Hence the time in which B will be raised over a given space h, being equal to as many seconds as h contains the above expression, is

$$\frac{\mathrm{A}\,a^2+\mathrm{B}\,b^2}{(\mathrm{A}a-\mathrm{B}\,b)b}\times\frac{2h}{g}.$$

It is evident that if A is given, as also B and b, and if the length of the arm a be alone supposed variable, the time thus computed must admit of a minimum, as it would be infinite if a were so short that $\mathrm{A}\,a=\mathrm{B}\,b$; and it would also be infinite if a were infinitely long. There must be a value of a, therefore, that will give the time of ascent the least, or the angular velocity of the lever the greatest; and it will be found by the preceding formula.

PART II. PRACTICAL MECHANICS.

THE subject of practical mechanics embraces various important topics, the most interesting and useful of which may be included under the following arrangement:

1. On mechanical agents, or the first movers of machinery.
2. On the form of the acting parts of machinery.
3. On the modes of applying the action of mechanical agents, and of producing from them any mechanical effect.
4. On the regulation of machinery by fly wheels, &c.
5. On Friction.

CHAP. I.

ON MECHANICAL AGENTS, OR THE FIRST MOVERS OF MACHINERY.

The powers which are usually employed on a great scale as the first movers of machinery, are, 1. The strength of men and animals; 2. The elastic force of steam; 3. The elastic force of heated air; 4. The force of water; and 5. The force of wind.

The method of employing water as the first mover of machinery, has already been fully explained in our article HYDRODYNAMICS. The application of the elastic force of steam to the construction of the steam engine, will be given at length under the article STEAM ENGINE; and the mode of using the elastic force of heated air, will be explained under the article PNEUMATICS, in our account of a very ingenious engine of this kind invented by the Rev. Robert Stirling of Kilmarnock, and actually used in practice. We shall, therefore, limit our observations at present to the following objects:

1. On the strength of man and animals.
2. On the force of wind, and its application to windmills.
3. A general view of the relative powers of mechanical agents.

SECT. 1. *On the Strength of Men and Animals.*

The form and construction of the human body renders it peculiarly applicable as the first mover of machinery, and what it wants in strength, is compensated to a great degree by the skill and judgment with which it can be applied. When we consider the great number of cases in which it is preferable to employ the action of men rather than that of inanimate agents, and the still greater number in which it is out of our power to employ any other, it becomes a matter of the highest importance, both to workmen and to those who employ them, to ascertain the way in which the greatest quantity of work can be obtained from their exertions, with the least quantity of bodily fatigue, or with such a quantity of fatigue as they can easily bear from day to day, without injuring their corporeal functions.

Daniel Bernoulli indeed maintained, that the degree of fatigue is always proportional to the quantity of action by which it is produced; that whether he walks, or carries a load, or draws, or pushes, or works at a winch, or raises a weight, he will always produce with the same degree of fatigue the same quantity of action, and therefore the same effect; and that the daily labour of a man, whatever be the work to which he is set, may be reckoned at 1,728,000 pounds raised through the height of one foot, or 60 pounds raised through the height of one foot in a second, when his day's labour amounts to eight hours. These opinions were adopted by almost all subsequent authors, on the authority of vague and inconclusive experiments, till the subject received a full investigation from the celebrated Coulomb.

1. The first experiments of Coulomb were intended to ascertain the quantity of action of men when ascending a stair, either loaded or unloaded.

He found that a man can ascend the stairs of a dwelling-house at the rate of 14 metres* in a minute, provided he does not ascend more than 20 or 30 metres. Hence, if we suppose the weight of the man to be 70 kilogrammes, the quantity of motion which he furnishes is

980 kilogrammes raised 1 metre in 1 minute;

and if we *suppose* him capable of continuing this for four hours a-day, his daily action will be

235,200 kilogrammes raised 1 metre in 4 hours.

M. Coulomb also found, that a man unloaded ascended to the height of 150 metres by steps cut in a rock, in the space of 20 minutes; but he could not engage any of the workmen for the ordinary day's wages to do this 18 times a-day, or to continue it 6 hours.

When M. Borda and his party ascended the Peak of Teneriffe, eight men, principally sailors, ascended 2923 metres (9593 feet) the first day's journey, from nine o'clock in the morning to half-past five in the afternoon, having halted 3-4ths of an hour to dinner, so that they ascended that height in 7 and 3-4ths hours. This experiment gives us, for the daily action of each, 204,610 kilogrammes raised 1 metre in 7 3 4ths hours, which may be considered as the work of a day.

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* We have retained the French weights and measures, because, in reducing them to English ones, the results would be constantly in decimals, which would have the appearance of a degree of accuracy which the subject does not admit of.

We may therefore follow Coulomb, in considering that a man can easily ascend a convenient stair with the same quantity of action, and that

205 kilogrammes raised 1 kilometre

is rather too low than too high an estimate of the daily quantity of action which a man can in this way furnish†.

In order to compare this quantity of action with that which a man can furnish when loaded, Coulomb found, that a man loaded with fire-wood could furnish a quantity of action in a day of

109 kilogrammes through 1 kilometre.

Another man, of unusual strength, in doing the same work, furnished a quantity of action of

129 kilogrammes through 1 kilometre;

but he over-exerted himself to such a degree, that he was unable to work during the two following days.

If we take even this result, which is an extreme one, the quantity of action which a man can furnish unloaded, is to that which he can furnish when loaded, in the ratio of 205 to 129, or of 16 to 10.

In this estimate, Coulomb has omitted the quantity of action spent in the descent of the stair, because it does not amount to more than the 25th part of the daily work.

Let us now follow Coulomb in considering what load a man ought to carry in order to produce the greatest *useful effect*. When a man ascends a stair loaded, he raises his own weight along with his load, and at every turn he descends without a load; but the only useful effect which he produces is the conveyance of the load. Now, if the load were gradually increased, the total quantity of his daily action would diminish; and if it amounted to 150 kilogrammes, he would scarcely be able to move with it. On the other hand, if he ascended without a load, yet, though his actual quantity of action would then be a maximum, the load, and consequently the useful effect, would be nothing. Between these two limits, therefore, there will be a certain load which will give a maximum effect.

Now, since a man unloaded furnished a daily quantity of action of

205 kilogrammes through one kilometre,

and a man loaded with 68 kilogrammes,

109 kilogrammes through 1 kilometre,

it follows, that a load of 68 kilogrammes diminished his quantity of daily action

96 kilogrammes through 1 kilometre.

But supposing that the quantities of action lost are proportional to the loads, and calling P the load, the analogy $68 : 96 = P : \frac{96}{68} P$, or 1.41 P, or 1.41 kilometres, multiplied by P, will give the quantity of action lost. Hence the quantity of action furnished under the load P will be $205 - 1.41\ P$, where 205 is 205 kilogrammes raised through 1 kilometre, and 1.41 represents 1 kilometre and 41 hundredths, the height to which the weight P is raised. If we now call $h =$ height to which the man ascends with the load P which he is able to raise during a day, then, if his own weight is 70 kilogrammes, P h will represent the useful effect of his work, and $(70+P)\ h$ will be his total quantity of daily action. Hence we have,

$$(70+P)\ h = 205 - 1.141\ P,$$

and by reduction, we obtain for the useful effect

$$P\ h = \frac{P\ (205 - 1.41\ P)}{70+P};$$

and making $205 = a$, $1.41 = b$, and $70 = W$, we shall have

$$P\ h = \frac{P\ (a - b\ P)}{W+P};$$

which will be a maximum when

$$P = W\left(\sqrt{1+\frac{a}{b\ W}} - 1\right) = 0.754\ W = 53 \text{ kilogrammes.}$$

If we now substitute the value of P, or 53 kilogrammes, in the formula

$$P\ h = \frac{P\ (205 - 1.41\ P)}{70+P},$$

we shall have $P\ h = 56$ kilogrammes raised through 1 kilometre, which is a measure of the useful effect of a man carrying a load up a stair; and, therefore, this mode of employing a man consumes nearly 3-4ths of his real action, and he will cost, therefore, four times more than a man who, after having ascended the stair unloaded, raises a weight by allowing himself to descend by gravity through the height to which he ascended.

Let us suppose that the man is so loaded as to produce no work, which is when he bears the greatest weight which he can carry; then in this case,

$$205 - 1.41\ P = O, \text{ and } P = 145 \text{ kilogrammes,}$$

which is actually the weight which an ordinary man can just carry.

The formulæ, therefore, which Coulomb has given, correspond to the *maximum* of the total action of a man ascending a stair unloaded; to the *minimum* of action when he is loaded with a weight which he can just carry; and also to an intermediate quantity of action of 68 kilogrammes, the ordinary load of men ascending stairs when loaded.

Mr. Playfair has simplified these formulæ considerably, by altering a little one of Coulomb's results, and supposing that when a man carries a load equal to his own weight, his action is reduced one-half. Coulomb found the reduction of action to be from 205 to 96 when the load was 68; the weight of a man being reckoned at nearly 70 kilogrammes. The same notation being used as before, and H being the height to which he ascends in a given time, walking freely, his action when he ascends loaded, or $(W+P)\ h$, will be reduced to

$$WH\ \left(1 - \frac{P}{2W}\right), \text{ and therefore}$$

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* In the ascent of the Peak, the sailors actually descended 1-50th of the whole ascent in order to obtain wood for kindling the fire.

$$h = \frac{HW\left(1 - \frac{P}{2W}\right)}{W + P}, \text{ and } P\,h = \frac{WHP\left(1 - \frac{P}{2W}\right)}{W + P}$$

which will be a maximum when

$$P = W\,(+\sqrt{3}), \text{ or when}$$
$$W : P = 1 : -1 + \sqrt{3} = 4 : 3 \text{ nearly.}$$

If in the preceding value of h. P and h are supposed variable, the other quantities being constant, the locus of the equation will be a hyperbola.*

The formulæ given by Coulomb may be rendered still simpler than those of Mr. Playfair, and with exactly the same result, by considering that $a = 3\,Q$ nearly, and by taking $1.41 = 1\frac{1}{2}$. By substituting these quantities in in the formula $P\,h = \frac{(a - b\,P)\,P}{W + P}$, we obtain

$$P\,h = \frac{(3\,W - 1\frac{1}{2}\,P)\,P}{W + P}, \text{ and } h = \frac{3\,W - 1\frac{1}{2}\,P}{W + P},$$

which becomes a maximum when

$$P = W(\sqrt{3} - 1) = 0.732\ W.$$

When $P = 2\,W$, we have $3\,W - 1\frac{1}{2}\,P = 0$, and $h = 0$, which shews that when the load is equal to twice the weight of the man, he loses the power of ascending.

M. Coulomb proceeds next to consider the quantity of action which a man can furnish when he walks on a horizontal road, either loaded or unloaded.

When a man travels for several successive days, and without any load, he can easily walk 50 kilometres in a day, which gives for his quantity of action

3500 kilogrammes carried 1 kilometre.

Coulomb found also, that porters, carrying furniture equal to 58 kilogrammes a load, had a quantity of action equal to

2048 kilogrammes carried 1 kilometre.

From which it follows, that the daily quantity of action of a man travelling unloaded, is to the quantity when he is loaded with 58 kilogrammes, as 7 to 4 nearly.

He likewise found, that carrying a load of 44 kilogrammes had a quantity of action equal to

2166 kilogrammes carried 1 kilometre.

For various reasons, Coulomb assumes as the best results, when the load is 58 kilogrammes,

2000 kilogrammes carried 1 kilometre.

Now it is obvious, that the quantity of action lost by carrying a load is

1500 kilogrammes carried 1 kilometre.

And if we suppose that the losses of action are proportional to the load, we shall have

$$58 : P = 1500 : \frac{1500}{58}\,P = 25.86\,P,$$

and the real quantity of action will be $3500 - 25.86\,P$, and making this equal to 0, we obtain $P = 135.4$ kilogrammes for the greatest load which a man can carry, which coincides nearly with a former result.

If we now call d the distance through which he can carry the weight P, and W the weight of the man as before, we have $(P + W)\,d$ for his quantity of action; and therefore,

$$(P + W)\,d = 3500 - 25.86\,P, \text{ and } P\,d = \frac{(3500 - 25.86\,P)\,P}{P + W}; \text{ or,}$$

calling $3500 = a$, $25.86 = b$, we have $P\,d = \frac{(a - b\,P)\,P}{P + W}$,

which is a maximum when $P = W\left(\sqrt{1 + \frac{a}{bW}} - 1\right)$, or $P = 0.72$

The formulæ thus given by Coulomb may be simplified, and reduced to the very same as those formerly given, by considering that $a = 50\ W$, and by taking the coefficient of P at 25 instead of 25 86. Hence we have

$$P\,d = \frac{(50\,W - 25\,P)\,P}{P + W}, \text{ and } d = \frac{50\,W - 25\,P}{P + W}, \text{ which}$$

becomes a maximum when $P = W(\sqrt{3} - 1) = 0.732\ W$.

When $P = 2\,W$, then $50\,W - 25\,P = 0$, and $d = 0$, which shews that when the load is equal to twice the weight of the man, he can no longer carry it.

It is a singular circumstance, that the ratio between P and W, when the effect is a maximum, should turn out so exactly the same in the two cases of a man carrying a burden on a level road and up a pair of stairs, and that this should take place by such a slight change upon the numbers given by Coulomb. This coincidence cannot fail to be considered as a proof of the accuracy of Coulomb's results; for unless the ratio of P to W in the case of a maximum varied with the inclination of the path, there can be no reason why it should not remain the same when the path was horizontal. The ratio obtained by Coulomb in the two cases were,

In ascending a height	$P = 0.754\ W$
In treading along a horizontal plane .	$P = 0.72\ \ W$
Mean.	$P = 0.737\ W$;

a mean which is almost exactly the same as the result, viz. $P = 0.732\ W$, which we have found for both cases.

The next case considered by Coulomb, is that in which the porters return unloaded to carry away a new load.

Calling $D = 50$ kilometres, the distance a man can travel unloaded, and x the space through which he travels unloaded in the course of his day's labour, then WD will be his quantity of action when he travels all day without a load, and $W\,x$ will be a portion of his day's journey. If we divide this portion of work by WD, the whole of his day's work, we shall have $\frac{W\,x}{WD} = \frac{x}{D}$, the portion of his day's work when he is unloaded, the whole day's work being unity, for when $x = D$, then $\frac{x}{D} = 1$.

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* Playfair's *Outlines of Natural Philosophy*, vol. i. p. 114.

But since the man travels over the same space x loaded, and since his daily quantity of action when loaded with a weight P is equal to 3500—25.86 P, the portion of his action under the load P will be $(P+W)x$, and the ratio of this quantity with the daily quantity of action, or $\frac{(P+W)x}{3500-25.86P}$ will represent the portion of his daily work which he furnishes under the load P. Hence, the sum of the quantity when unloaded, and the quantity when loaded, will be equal to the labour of the whole day, or $\frac{x}{D}+\frac{(P+W)x}{3500-25.86P}=1$.

But since $WD=3500$, then making $b=25.86$, we shall have, by reducing the above equation,

$$Px=\frac{P(WD^2-bDP)}{2WD+P(D-b)}$$

or the portion of action which is equal to the useful effect which a man can furnish in a day.

Now, making $a=WD^2$: $c=bD$, $e=2WD$, and $P=D-b$, we shall have

$$Px=\frac{aP-cP^2}{e+fP},$$

which will be a maximum when

$$P=\frac{e}{f}\left(\sqrt{1+\frac{fa}{ce}}-1\right)$$

which becomes, by substituting the numerical values in place of the letters,

$P=61.25$ kilogrammes, and since $W=70$, $P=0.9W$.

The preceding formulæ, as given by Coulomb, will admit of being greatly simplified, by considering that $WD=50W$, that $D=50$, and by taking $b=25=\frac{1}{2}D$. By these substitutions we have

$$Px=\frac{P(2500W-25D^2P)}{\frac{1}{2}D(100W+P)},$$

which will be a maximum when

$$P=280\left(\sqrt{1\tfrac{1}{2}}-1\right), \text{ or}$$

$P=62.928$ kilogrammes, or

$P=0.8989$ W,

a load very nearly equal to that which is usually carried by porters under the circumstances of the present case.

By substituting the value of $P=61.25$ in Coulomb's formulæ, we shall obtain $Px=692.4$ kilogrammes carried through 1 kilometre, as the daily quantity of action which a man can furnish in this kind of work. If we make $P=58$, we shall have $Px=691$, and if we make $P=65$, we shall have $Px=690$, which shews that a variation of 4 or 5 kilogrammes in the load, produces scarcely any change in the maximum of useful effect.

From the above results it follows, that the quantity of action furnished by a man walking unloaded, and a man walking under the circumstances of the present case, is as 505 to 100, or nearly as 5 to 1.

Although the quantities of action of a man ascending a stair is not of the same kind with that of a man walking freely on a horizontal road, yet it is interesting to compare them together, as Coulomb has done.

The quantity of action in these two cases are as 2[illegible]5 to 3500, or as 1 to 17. Now, the ordinary height of a step is 135 millimetres, and its width thrice as great. Hence, 17×135=2295 millimetres, will be the length of horizontal road which a man can travel with the same degree of fatigue which he experiences in ascending a step of 135 millimetres, and as the pace of a man is 650 millimetres, it follows, that a man experiences the same degree of fatigue in ascending one step of 135 millimetres as in advancing three paces and a half.

Having thus followed Coulomb through the most general and most useful part of his investigation, we shall present the remainder of his results, along with those which we have already given, in a tabular form.

Table shewing the Quantity of Action which a Man can furnish in a Day, when his strength is exerted in various ways.

	Kilogrammes.			
1. When he walks on level ground unloaded	2500	carried	1	kilometre.
2. When he walks loaded with 58 kilogrammes, and returns unloaded for another burden, the *useful effect* is	692.4		1	do.
3. When he walks always loaded	912		1	do.
4. When a man carries a load on a wheelbarrow, the *useful effect is*	1022.7		1	do.
5. When a man ascends a stair unloaded, *the mechanical effect is*	205		1	do.
6 When he raises a weight for driving piles, *the useful effect is*	75.2		1	do.
7. A man coining money by raising a weight*	39.5		1	do.
8. When he ascends a stair loaded with 53 kilogrammes, *the useful effect is*	56		1	do.
9. When he draws water from a well by a double bucket, the *useful effect is*	71		1	do.
10. When he exerts himself in turning a winch	116		1	do.
11. When he digs with a spade	62.3		1	do.

Such are the leading results of Coulomb's experiments. They completely refute the idea of Bernoulli, and establish many points of singular importance. We would recommend them to practical men as deserving their particular study, and as likely to be of great advantage to those who may judiciously carry them into effect on a large scale.

The following results, given on the same scale as those of Coulomb, have been collected by M. Hachette. The number expressing the kilogrammes, both in this and the preceding Table, are called by the French writers *dynamical units*, a dynamical unit being the weight of a cubic metre of water, raised to the height of a metre. Hence, the number of kilogrammes that are raised one kilometre are dynamical units.

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* This result is so much less than the preceding, because at the Mint the men wrought 15 months in succession; whereas, those who drove piles went to another kind of work when they were fatigued.

		Kilogram.		Kilom.
1.	A man weighing 70 kilogrammes, who walks 7½ hours a day, on a declivity of 14 centimetres to 1 metre, with a load of 7 or 8 kilogrammes	225	raised	1
2.	A man marching in a mountainous country with a load	140		1
3.	A porter carrying wood up a stair (the weight of the porter included)	109		1
	N. B.—This is the case, No. 6. of Coulomb's Table, where we did not include the weight of the porter.			
4.	A porter carrying coals up a stair, the weight of the porter included	112 to 120		1
5.	A man raising a weight by a pulley	40		1
6.	A man raising a weight by a pulley for driving piles	48		1
	N. B.—This result was obtained by M. Lamande, from the work of 38 men, who raised a weight of 587 kilogrammes for driving piles.			
7.	A man drawing a boat *a la bricole*	110		1

In the following examples, the dynamical unit is a cubic metre of water carried a metre upon a horizontal road.

8.	A soldier loaded with from 20 to 25 kilogrammes, and travelling 20 kilometres a day	1800 to 1900	carried	1
9.	A Roman soldier on forced marches of 40 kilometres a day	4400 to 4800		1
10.	Hawkers with crotchets (weight of man not included)	792 to 880		1
11.	Porters drawing a small waggon on 4 wheels over ground pretty unequal, and often clayey. Guinevau *Essais sur les Machines*, p. 271.	626		1
12.	Porters drawing a small waggon on 4 wheels, *running upon horizontal planks*	900 to 1000		1
13.	Do. running on the ground, where there are inequalities of surface	600		1
14.	A man drawing a boat on a canal (50 thousand kilogrammes transported 11 kilometres)	550,000		1

Before we conclude this part of the subject, we shall subjoin various other estimates of the force of men and horses, which may be of use in particular cases, though the results have been generally obtained from experiments not very judiciously conducted.

Table of the Strength of Men, according to different Authors.

Number of pounds raised.	Height to which the weight is raised.	Time in which it is raised.	Duration of the Work.	Names of the Authors.
1000	180 feet	60 minutes		Euler
60 French	1 French	1 second	8 hours	Bernoulli
25 French	220 French	145 seconds		Amontons
170 French	1 French	1 second	half an hour	Coulomb
1000	330	60 minutes		Desaguliers
1000	225	60 minutes		Smeaton
30	3½	1 second	10 hours	Emerson
30	2.43 feet	1 second		Schulze

According to M. Amontons, a man weighing 133 French pounds ascended 62 French feet by steps, but was completely exhausted.

A sawyer, according to the same author, made 200 strokes of 18 French inches each, with a force of 25 pounds, in 145 seconds.

An ordinary man, according to Desaguliers, can turn a winch with the force of 30 pounds for 10 hours, with a velocity of 2½ feet per second.

Two men, according to Desaguliers, working at a windlass with handles at right angles to each other, can raise 70 pounds more easily than one man can raise 30, an additional effect of five pounds being produced on the work of each man, in consequence of the uniform action arising from the handles being at right angles to each other.

A man may, according to the same author, exert a force of 80 lbs. with a fly, when the motion is pretty quick.

A man may also, with a good pump, raise a hogshead of water 10 feet high in a minute, and continue the work for a whole day.

According to Dr. Robison, a feeble old man raised 7 cubic feet of water, =437½ lbs. avoirdupios, 11½ feet high in a minute, for 8 or 10 hours a-day, by walking backwards and forwards on a lever.

A young man, weighing 135 pounds, and carrying 30 pounds, raised 9¼ cubic feet of water, $=578\frac{1}{10}$ lbs. avoirdupois, 11½ feet high, for 10 hours a-day without being fatigued.

According to Mr. Buchanan, the forces exerted by a man acting at a winch, pumping, ringing, and rowing, are as the numbers 1742, 2856, 3883, and 4095. Now, if we take Coulomb's measure of action for turning a winch, which is 116 kilogrammes through 1 kilometre, or 256 pounds avoirdupois through 3281, we shall have the

Nature of the Action.	Mechanical Effect. Kilog. Kilom.	lbs avoird.	Feet.
Mechanical effect of turning a winch . .	116 through 1	256	3281
Mechanical effect of pumping . . .	190 through 1	419	3281
Mechanical effect of ringing . . .	259 through 1	572	3281
Mechanical effect of rowing . . .	273 through 1	608	3281

The following table contains the relative strength of horses, asses, and men.

1 horse is equal to	5 men,	Desaguliers. Smeaton.
1 - - -	7 men,	Bossut, &c.
1 - - -	14 men,	Schulze.
1 ass - -	2 men,	Bossut.

2 horses, according to Amontons, exert a force of 150 pounds when yoked in a plough.

1 horse, according to Desaguliers, can draw with a force of 200 lbs. 2½ miles an hour, and continue this action for 8 hours every day. When he exerts a force of 240 pounds, he can continue it only 6 hours every day.

1 horse, by means of pumps, can, according to Mr. Smeaton, raise 250 hogsheads of water 10 feet high in an hour.

1 horse walking on a good road, and loaded with about two hundred weight, can travel 25 miles in 7 or 8 hours.

1 horse raising coals by means of a wheel and axle, and moving at the rate of about 2 miles an hour, can, according to Mr. Fenwick, raise a load of 1000 pounds avoirdupois with a velocity of 13 feet per minute, and continue this for 12 hours.

1 horse, according to the same author, can exert a force of 75 pounds, moving at the rate of 13 feet per minute, and continue it for 9½ hours.

According to Regnier, the mean draught of 4 horses was 36 myriogrammes in 794 hours.

1 horse can draw more up a steep hill than 3 men can carry; that is, from 450 to 750 lbs. Desaguliers.

strong horse can draw 2000 lbs. in a cart up a steep hill which is but short. Desaguliers.

1 horse has sometimes carried 650 or 700 lbs. for 7 or 8 miles without resting, as its ordinary work. Desaguliers.

horse at Stourbridge carried 11 hundred weight of iron, or 1232 lbs. for eight miles. Desaguliers.

1 mule works in the West Indies, 2 hours out of about 18, with a force of about 150 lbs. walking three feet in one second. Cazand.

From Desaguliers' measure of the force of a horse already given, it follows that its force is,

	Pounds.		Foot.	
According to Desaguliers,	44 000	raised	1	in 1 min.
According to Smeaton,	22,916	- -	1	in 1
According to Mr. Watt,	33,000	- -	1	in 1

Mr. Watt's steam engines are, however, calculated to work equal to 44.000 lbs. raised 1 foot per minute, as he considers the difference, or 11,000 lbs. raised 1 foot per minute, to be lost in the friction, &c. of the engine itself.

The power of one horse is supposed capable of driving 100 spindles with preparation of cotton water twist. 1000 spindles with preparation cotton mule yarn, and 75 spindles with preparation flax yarn.

The following are the results respecting horses given by M. Hachette.

	Kilog.	Kilom.	Daily action, measured by the draught and the road travelled.	Useful effect in Dynamical Units.
1 A cart horse	140 ×	40 - - -	5600	
2. A post horse	90 ×	38 - - -	3420	
3. A horse moving in a circle, and working a pump, - - -				58
4. Id. working 12 hours, and raising plaster, - - - - -			1681	84
5. Mean of three horses working at a pump, - - - - -			1185	595
6. Mean of 8 horses raising water by a pump - - - - -			2948	674
7. Two horses raising coals, -			1560 doubtful.	
8. A horse drawing a load of 150,000 kilogrammes through 8 kilometres, - - - -			800	
9. The force of a horse acting 24 hours is equal to - - -			5974 dynamical units.*	

For farther information on this subject, see Daniel Bernoulli, *Prix de l' Acad. Par.* 1753, tom. vii. Desaguliers' *Exper. Phil.* vol. i. Euler, *Mem. Acad. Petrop.* 1750—1751, 1760,—1761. Lambert, *Mem. Acad. Berl.* 1776. Schulze, *Mem. Acad. Berl.* 1783. Dr. Thomas Young's *Nat. Phil.* vol. ii. Coulomb, *Mem. Instit.* tom. ii. 1799, p. 38. Perronet, *Oeuvres*, tom. ii. p. 46. Guineveau *Essais sur les Machines*. Hachette *Traité Elementaire des Machines*, Ed. 2d, 1819, p. 54.

SECT. II. *On the application of Wind as the first mover of Machinery.*

When wind is employed as the first mover of machinery, it may be applied in two ways: 1st, By receiving it upon sails which are nearly vertical, and which give motion to an axis nearly horizontal, in which case the machine is called a *vertical windmill*, because the sails move in a vertical plane; and 2d, By receiving it upon vertical sails which move in a horizontal plane, and give motion to a vertical axis, in which case it is called a *horizontal wind-mill*.

1. *On Vertical Wind-Mills.*

The sails of a vertical wind-mill, when they are only four in number, are shown in Plate CCCLXIV. Fig. 9. The form of the sails, as adopted in the best Dutch wind-mills, has been accurately given by M Coulomb, from the examination of more than 50 wind-mills in the neighbourhood of Lisle. These various machines were found to perform nearly the same quantity of work when the wind had a velocity of 18 or 20 feet per second, though some differences existed in the inclination of their axes or wind-shafts, and in the disposition of their sails; and from that circumstance Coulomb justly concluded, that the parts of the machine must have been constructed and disposed so as to produce nearly a maximum effect.

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* This result is deduced from the fact, that a horse can draw 140 pounds with the velocity of 200 feet in a minute

The length of the Dutch sails, from their extremity A to the centre O of the wind-shaft, was 33 feet. They had a rectangular form, and were a little more than 6 feet wide, 5 feet of which were formed of cloth stretched upon a frame, while the remaining foot consisted of a very light board. The sail commenced at *a* 6 feet from O; so that the length of the sail A *a* was 33—6= 27 feet. The line of junction of the board and the cloth formed on the side which faced the wind a curve sensibly concave at the commencement *a* of the sail, and the curvature diminished gradually till it vanished at its extremity. Although every line drawn parallel to *c m* or *d n* was curved, yet the surface *c m n d* may be regarded as composed of straight lines *m n*, *o p*, &c. *c d* having different inclinations to the line *c m*. The inclination of these lines to *c m*, or to the plane of their motion, is called the *angle of weather*. In the Dutch sails, the angle of weather at *a*, or the inclination of *m n*, was 30°, which gradually diminished till it was 12° in some curves, and 6° in others, varying between these numbers as the inclination of the wind-shaft MO varied from 8° to 15°. When sails thus constructed were adjusted to the wind, or were placed so that the wind blew in the direction of the wind-shaft OM, they received the impulse obliquely to their surface, so that by resolving this impulse into two forces, one acting in the direction of the wind-shaft, and therefore lost in pressing the wind-shaft against its pivot, and another acting at right angles to the wind-shaft, and employed solely in giving a rotatory motion to the sails, and consequently to the wind-shaft OM. The power thus communicated to the wind-shaft may be employed in giving motion to any kind of machinery.

In order to keep the wind-shaft always in the direction of the wind, which is obviously necessary, in order to make it act upon the sails with the greatest efficacy, a large wooden vane or weathercock is fixed at the extremity of a long horizontal arm lying in the same vertical plane with the wind-shaft; and the action of the wind upon this vane keeps it, and consequently the wind-shaft, in the direction of the wind. The same effect is sometimes obtained by supporting the whole machinery on a strong vertical axis, so that the adjustment may be made by a lever. When the wind becomes too strong, so as to injure the sails, contrivances are often applied to the wind-mill, in order to make them furl their sails, so that the wind shaft may always move with the same velocity.

As the commencement of the sail at *a* is only 6 feet from its axis, while its termination at A is 33 feet, it is obvious that the velocity of the point *a* is to that of A as 6 to 33. The action of the wind, therefore, upon A, is less powerful than upon *a*, in the same manner as the action of water upon a float-board diminishes as the velocity of the float-board increases. Now, if the sails had no weather, that is, if their surface were in the plane of their motion, the wind would have no effect in turning them round, but would be wholly employed in pressing the wind-shaft against its pivot. On the other hand, if the surface of the sails were inclined 90° to the plane of their motion, the wind would blow past them, and produce no effect whatever. There must, therefore, be some angle intermediate between 0° and 90°, which will produce a maximum effect. This angle will be found to be 35° 15′ 47″, if we consider the effect produced when the sail starts from a state of rest*. Hence Parent and Belidor have both recommended this as the proper angle of weather for wind-mill sails, without considering that the sail is actually in motion, and that different parts of it have different velocities, and must therefore have different angles of weather.

The celebrated Euler has pointed out this error in a most satisfactory manner, and has given the following formula for determining the variation in the angle of weather.

If *a* is the wind's velocity, and *c* the velocity of any given point of the sail, then a maximum effect will be produced when the tangent of the angle of the wind's incidence, or of the sail's inclination to the axis; or what is the same, when the cotangent of the weather of the sail at the point whose velocity is *c*, is to radius as

$$\sqrt{2+\frac{9\,c^2}{4\,a^2}}+\frac{3\,c}{2\,a} \text{ is to } 1.$$

In order to show the application of this formula, let OA, Fig. 9, the radius of the sail *c m n d*, be divided into six equal parts; and let the point *q*, equidistant from O and A, be the point of the sail which moves with the same velocity as the wind. Then since in this case we have the velocity of the point *q*, or $c=a$, when the sail is loaded to a maximum, we shall have, when $a=1$, the cotangent of the angle of the weather,

$$1\sqrt{2+\frac{9\,c^2}{4\,a^2}}+\frac{3\,c}{2\,a}=3.561=\text{Cotang. of } 15^\circ\ 41', \text{ the}$$

angle of weather at the point *q*.

Since the velocities of different points of the sail are as their distances from the axis, and since the velocity at the distance ½ O *a*, or the middle point *q*, is $= a$, we shall have

$$\begin{aligned} \text{Velocity at } \tfrac{1}{6}\,\text{OA}, \ c &= \frac{a}{3} \\ \tfrac{2}{6}\,\text{OA}, \ c &= \frac{2a}{3} \\ \tfrac{1}{2}\,\text{OA}, \ c &= a \\ \tfrac{2}{3}\,\text{OA}, \ c &= \frac{4a}{3} \\ \tfrac{5}{6}\,\text{OA}, \ c &= \frac{5a}{3} \\ 1\,\text{OA}, \ c &= 2a \end{aligned}$$

By using these different values of C, the formula will give the following measures of the angle of weather suited to different distances from the axis.

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* See Ferguson's *Lectures*, vol. ii. Appendix, p. 267, note.

Parts of the radius from the centre of motion at O.	Velocity of the sail at these distances, or values of c.	Angle of weather.		Angle with the axis.	
		Deg.	Min.	Deg.	Min.
	$\frac{a}{3}$	26	34	63	26
$\frac{2}{6}$	$\frac{2a}{3}$	20	6	69	54
$\frac{3}{6}$ or $\frac{1}{2}$	a	15	4	74	19
$\frac{4}{6}$ or $\frac{2}{3}$	$\frac{4a}{3}$	12	40	77	20
$\frac{5}{6}$	$\frac{5a}{3}$	10	33	79	29
1	$2a$	9	0	81	0

This variation of the angle of weather, so clearly indicated by theoretical considerations, has been sanctioned by Mr. Smeaton's experiments. He found that the common practice of giving plain sails a weather of from 18° to 15° was much more efficacious than the angle assigned by Parent and Belidor, the effects being as 45 to 31. When the sails were weathered in the Dutch manner, that is, when their surfaces were concave to the wind, and when the angle of weather diminished towards their extremities, the effect was much greater than when they were weathered either in the common way, or according to Euler's formula. When the sails were enlarged at their outer extremities, as shown in Plate CCCLXIV. Fig. 10, so that *a b* was $\frac{1}{3}$ of the radius OA, and *a* A to A *b* as 5 to 3, their power was then the greatest of all, though the area of the sail exposed to the wind remained the same. By enlarging the sails still farther, Mr. Smeaton found that the effect was not increased in proportion to the surface. In Mr. Smeaton's experiments, he made the angle of weather vary as the distance from the axis; and he found the following angles to be the most efficacious.

Table of the Angles of Weather given by Mr. Smeaton.

Parts of the radius OA, which is divided into 6 parts	Angle of weather.	Angle with the axis.
1	18	72
2	19	71
3	18 middle.	72
4	16	74
5	12½	77½
6	7	83

Euler, Parent, and others, have proposed to make the sails sectors of an ellipse, and to intercept the whole cylinder of wind; but it has been proved by later experiments, that the wind does not produce its greatest effect when the whole area is filled up with sail, from the want of proper interstices to escape.

On the relative Effects of Windmill Sails.

The principal results which have been published respecting the effect of wind-mill sails, have been obtained by Mr. Smeaton and M. Coulomb.

The following are the maxims deduced by Mr. Smeaton from his experiments.

Maxim 1. The velocity of wind-mill sails, whether unloaded or loaded, so as to produce a maximum effect, is nearly as the velocity of the wind, their shape and position being the same.

Maxim 2. The load at the maximum is nearly, but somewhat less than, as the square of the velocity of the wind, the shape and position of the sails being the same.

Maxim 3. The effects of the same sails at a maximum, are nearly, but somewhat less than, as the cubes of the velocity of the wind.

Maxim 4. The load of the same sails at the maximum is nearly as the squares, and their effects as the cubes of their number of turns in a given time.

Maxim 5. When sails are loaded, so as to produce a maximum at a given velocity, and the velocity of the wind increases, the load continuing the same: 1*st*, The increase of effect, when the increase of the velocity of the wind is small, will be nearly as the squares of those velocities: 2*dly*, When the velocity of the wind is double, the effects will be nearly as 10 : 27½: But, 3*dly*, When the velocities compared are more than double of that where the given load produces a maximum, the effects increase nearly in the simple ratio of the velocity of the wind.

Maxim 6. In sails where the figure and positions are similar, and the velocity of the wind the same, the number of turns in a given time will be reciprocally as the radius or length of the sail.

Maxim 7. The load at a maximum that sails of a similar figure and position will overcome, at a given distance from the centre of motion, will be as the cube of the radius.

Maxim 8. The effects of sails of similar figure and position are as the square of the radius.

Maxim 9. The velocity of the extremities of Dutch sails, as well as of the enlarged sails, in all their usual positions when unloaded, or even loaded to a maximum, are considerably quicker than the velocity of the wind.

On the absolute Effects of Windmills in manufacturing Oil of Colza.

In the windmills at Lille, examined by Coulomb, which were used for the preparation of oil of Colza, an arbor was furnished with 14 wipers, or radii, for the purpose of raising seven stampers. Five of these stampers were made of oak, and were about 7 inches long, and 28 centimetres square. They were shod with iron, weighing about 25 or 30 kilogrammes, and served to bruise the seeds, the weight of each being about 500 kilogrammes. The other two stampers, which had the same length, but were only 19 or 20 centimetres square, were used to lock and unlock the wedges for extracting the oil by a strong compression, and weighed about 250 kilogrammes each. Of these two last only one acted at a time; but the other five all acted together.

Exp. 1. When the velocity of the wind was 2.27 metres in a second, the sails revolved 5½ times in a minute when the mill was unloaded, and no stampers raised; but by putting into action one stamper weighing 510 kilogrammes, and striking two blows of 49 centimetres in height, the mill scarcely made three turns in a minute.

Exp. 2. When the velocity of the wind was 4.06 metres in a second, the arbor made from 7 to 8 turns in a minute; and when two of the stampers were put in action that weighed 510 kilogrammes, and one of 250 kilogrammes, the mill prepared 1 ton, or 100 kilogrammes of oil in 24 hours.

Exp. 3. When the velocity of the wind was 6.5 metres in a second, the arbor made 13 turns in a minute; and when five of the stampers weighing 510 kilogrammes were put in action, and one of 250 kilogrammes, the mill prepared 3½ tons of oil in 24 hours. With this velocity, the wind blew uniformly, the mill carried all the sails without straining the carpentry, and the velocity appeared to be that which was best suited to the machine.

Exp. 4. When the wind blew with force at the rate of about 9.1 metres in a second, it was necessary to take in an area of two metres of sail at the extremity of each sail. The arbor made from 17 to 18 turns in a minute, and the mill prepared with all its six stampers in action, 5 tons of oil in 24 hours.

Exp. 5. On an average of several years, each windmill prepares annually 400 tons of oil. Each ton consumes from 14,000 to 15,000 dynamical units of the force transmitted by the stampers. Coulomb supposes, that the blows of the stampers, and the action of the wipers and friction, absorb one-sixth of the force transmitted to the stampers, which reduces to 12,500 the number of dynamical units necessary for preparing 100 kilogrammes of oil.

The preceding result is confirmed by a very important experiment made by M. Halle at Lille, on a steam engine of 10 horses' power, which he found to prepare in 24 hours 500 kilogrammes of oil. Now, the power of a horse has been reckoned at 5974 dynamical units; consequently, 10×5974=59740, which, divided by 5, gives 11948 for the number of units employed in preparing 100 kilogrammes of oil.

Effect of Windmills in grinding Corn.

When a wind-mill is employed to grind corn, the mill-stone makes five revolutions in the same time that the sails and the arbor make one.

Exp. 1. The mill does not begin to turn till the velocity of the wind is about 4 metres per second.

Exp. 2. When the velocity of the wind is 5.8 metres per second, the sails make from 11 to 12 turns in a minute, and the mill will grind from 400 to 450 kilogrammes in an hour, or about 100,000 kilogrammes in 24 hours.

Exp. 3. When the velocity of the wind is 9.1 metres in a second, the mill carries all her sails, makes 22 turns in a minute, and grinds 900 kilogrammes of flour in an hour, or 21,600 in 24 hours. With this velocity, the flour is heated to a considerable degree, and the millers change from time to time the kind of grain which is ground, in order, as they say, to refresh the mill.

By comparing the preceding experiments, and considering that seven horses, or one man, can grind 167 kilogrammes of corn in a day, it will be found that the grinding of 100 kilogrammes of corn consumes 416, 525, or 538 dynamical units. The first of these numbers is obviously too small, and M. Hachette concludes, in general, that the preparation of 100 kilogrammes of corn corresponds to a dynamical effect of the arbor of a wind-mill equal to 500 or 550 units.

In examining the ratio between the velocity of the wind and the number of revolutions of the wind's height or arbor, Mr. Smeaton obtained the following results for Dutch sails in their common position, when their radius was 30 feet.

Number of revolutions in a minute.	Velocity of the wind *per hour.*	Ratio.
3	2 miles per hour.	0.666
5	4	0.800
6	5	0.833

The following results are deduced from the above experiments of Coulomb.

No. of Experiments.	No. of turns in a minute.	Velocity of the wind in a second	Velocity of the wind per hour in miles.	Ratio of Col. 2. & 4.
1	3	2.27 metres.	5.1	1.7
2	7 to 8	4.06	9.14	1.22
3	13	6.5	14.6	1.05
4	17 to 18	9.1	20.4	1.17
5	11 to 12	5.8	13.0	1.13
6	22	9.1	20.4	0.93

These results differ widely from those of Smeaton; but we must consider that the mill was not doing its full work, except in experiments 3, 4, 5 and 6. The average of the ratios from these experiments will be 1.07, the ratio between the number of turns in a minute and the number of miles an hour. Hence, by multiplying the number of turns per minute by 1.07, we shall have an approximate measure of the velocity of the wind.

Mr. Lulofs of Leyden found, that a Dutch wind-mill employed to drain marshes was capable of raising 1500 cubic feet of water four feet high in a minute, when the wind moved at the rate of 30 feet per second. It had four rectangular sails, and the mean angle of weather was 17°.

In the Dutch windmills of the dimensions formerly stated, Coulomb found, when the velocity of the wind was 20 feet per second, that the effect was equivalent to 1000 pounds raised through 218 feet in a minute. The force lost by the action of the wipers upon the stampers was equal to 1000 pounds raised through 16½ feet in a minute, and the friction was equivalent to 1000 pounds raised through 18½ feet in a minute. Hence the total force of the wind was equal to 1000 pounds raised through the height of 253 feet in a minute.

On Horizontal Windmills.

As a horizontal windmill consists of vertical sails moving horizontally round a vertical arbor or wind-shaft, it is evident that no motion would arise from exposing it to the action of the wind, as the effect of the wind upon the sails on one side would be counterbalanced by its action upon the corresponding sails on the opposite side. Hence it is necessary either to screen the sails on one side from the action of the wind, or to construct the sails in such a manner, that, when they return against the wind, they present only their edge to its action. The method of screening the returning sails from the wind is adopted in Tartary and some provinces of Spain, and is probably the best, because it is the most simple of any method that has been tried. When the screen is not used, the sails may be fixed like float-boards, with hinges, on the circumference of a large drum or cylinder, so that, when they are to receive the action of the wind, they stand at right angles to the drum; and, when they return against the wind, they fold down upon its circumference*. The method of Mr Beatson, which we have represented in Fig. 11. Plate CCCLXIV. is however preferable to this. It consists in forming each sail out of six or eight flaps or veins, AP b 1, b1 c 2, moving upon hinges represented by the dark lines AP, b 1, c 2, &c.; so that the lower side b 1 of the first lap overlaps the hinge, or highest side of the second flap, and so on. Consequently, when the wind blows upon the sail AI, each flap will press upon the hinge of the one immediately below it, and the whole area of the sail will receive its action. When the sail AI, however, returns against the wind, the flaps will revolve upon their hinges and present only their edges to the wind, as is shown at EG; so that the motion of the sails will be continued by the superiority of the force acting upon the sails in the position AI. Mr. Beatson has computed, that when the pressure upon the sail AI is 1872 pounds, the action of the wind upon the edges of the returning sails is only 36 pounds, or $\frac{1}{52}$ of the whole; but it has been shown†, that this latter action will be about 96 pounds, or $\frac{1}{20}$ of the whole.

A new and very ingenious method of bringing back the sails against the wind, has been invented by Mr. George Buchanan of Edinburgh, and is represented in Plate CCCLXIV. Figs. 12, 13, 14, 15, 16, and 17. In this method, the sails, as in other horizontal windmills, are attached to the horizontal arms of the vertical axis of the mill, the prime mover of the machine. Each of them is besides moveable horizontally round an axis of its own, which passes through the middle of it, and is bushed at the top and bottom into the extremities of the arms of the principal axis; and while this axis revolves by the effect of the wind, and carries the sails along with it, the method of bringing up the sails to windward consists in giving at the same time to each of them, on its own axis, a rotatory motion *in the opposite direction, and with half the angular velocity.* ABC, (Fig. 12.) represents the principal axis moveable in bushes at A and B; DEBFG, is any erection raised to support it. HI, KL, are two of the arms, with the sails M, N at the extremities. It is obvious, that if the opposite sails M, N were standing in the same direction, and thus equally exposed to the wind, no motion whatever would ensue, as the actions on the sails being in that case equal and contrary would mutually balance each other. To produce any motion at all, therefore, one of the sails must, as in every other kind of horizontal mill, be withdrawn from the influence of the wind. In the present machine, this is done by means of the rotatory motion above mentioned, the sail, which at M is fully exposed to the wind, turning itself gradually away from it as it approaches to N—presenting its face to it on the one hand, and its edge to it on the other, as at Figs. 13, 14, 15, 16, which represent ground plans of four successive positions of the arms and sails, the wind blowing in the direction of the arrows.

While the great axis and sails make a complete revolution in the direction MONP, each sail M makes half a revolution in the opposite direction, so as to assume successively as it arrives at O, N, P, the successive positions at ab, cd, ef, gh, (Fig. 13.) the positions also at Figs. 14, 15, and 16, and all the intermediate ones. This method of bringing back the sails has the advantage which every slow motion in mechanics is known to possess, when applied to bodies, like the sails, of considerable size and weight. It is superior, on this account, to the mode which has been proposed, of making the wind itself turn them upon hinges, in the manner of valves; the wind in this case, if they have any great weight, often dashing them violently round, to the great injury of the machine. It has also the peculiar property, that the sails impel the machine almost in every part of its course—beating up, as it were, against the wind; never retarding the motion, even in their return, and only not accelerating it at the point N, where the sail has no effect at all, except what arises from the effect of the wind on its edge. This method also admits a greater surface of sail to be exposed to the wind than any other horizontal mill; as not only almost the whole area between the axis and the extremities of the arms may be filled up, but exactly as much more beyond each arm. Lastly, even with the same surface of sail, it nearly doubles the power of the ordinary horizontal mills, by always exposing at least two of the sails at a time to the action of the wind. In various models of this machine which Mr. Buchanan has constructed, the rotatory motion of the sails was communicated to them from a wheel in the centre, by means of an axis and pinions, as represented in the section at Fig. 17, where a b is a toothed wheel attached to EF, and remaining stationary, while the mill goes round; bc is a toothed pinion working into the wheel a b, and putting itself in motion round its axis e d, as this axis, attached to the arm HI, moves round with the principal axis AC, through which it also passes at k. Lastly, f, g are two pinions fixed to the extremities of the axis c d, and working into the two wheels h, i, which being fixed to the axes of the sails, move them round at the same time, and with a velocity which, depending on the relative number of teeth in the wheels and pinions, it is easy to adjust to the exact half of that of the principal axis—the motion of rotation of the sails to the exact half of their motion of revolution, or to any other proportion. The sails being equally balanced on their axes, move round with great ease, and as the wind also blows equally upon each half of every sail, there will be very little strain on any of these wheels, pinions or axes. The wheel a b is moveable round its axis, so that it may be shifted into any position, and keep the sails always to the wind. This shifting is also done by the wind itself operating on a vane or small mill, and even regulating the velocity of the machine in high or low winds, by exposing the sails more or less obliquely to their action. On the whole there seems no practical objection to the construction of this machine; and as it could be erected at much less expense than a vertical mill, it might on many occasions prove of great utility.

In estimating the relative effects of vertical and horizontal wind-mills, Mr. Smeaton observes, that when the sails of a horizontal and a vertical mill are of the same dimensions, the power of the latter is four times that of the former, because, in the first case, only one sail is acted upon at once, while, in the second case, all the four receive the impulse of the wind. This, however, is not strictly true, since the vertical sails are all oblique to the direction of the wind. Let us suppose that the area of each sail is 100 square feet; then the power of the horizontal sail will be 100, and the power of a vertical sail may be called $100 \times \overline{\text{sine } 70^{\circ}}^{2}$ (70° being the common angle of inclination) $=0.88$ nearly; but since there are four vertical sails, the power of them all will be $4 \times 0.88 = 3.52$; so that the power of the horizontal sail is to that of the four vertical ones as 1 to 3 52, and not as 1 to 4, according to Mr. Smeaton. But Mr. Smeaton also observes, that if we consider the farther disadvantage which arises from the difficulty of getting the sails back against the wind, we need not wonder if horizontal wind-mills have only about $\frac{1}{8}$ or $\frac{1}{10}$ the power of the common sort. We have already seen, that the resistance occasioned by the return of the sails, amounts to $\frac{1}{20}$ of the whole force which they receive; by subtracting $\frac{1}{20}$, therefore, from $\frac{1}{3.52}$, we shall find that the power of horizontal wind-mills is only $\frac{1.03}{4.40}$, or little more than $\frac{1}{4}$ that of vertical ones. This calculation proceeds upon a supposition, that the whole force exerted upon vertical sails is employed in turning them round the axis of motion; whereas a considerable part of this force is lost in pressing the pivot of the axis or wind-shaft against its bed. Mr. Smeaton has overlooked this circumstance, otherwise he could never have maintained that the power of four vertical sails was quadruple the power of one horizontal sail, the dimensions of each being the same. Taking this circumstance into the account, we cannot be far wrong in saying, that in theory at least, if not in practice, the power of a horizontal windmill is about $\frac{1}{4}$ of the power of a vertical one, when the quantity of surface and the form of the sails is the same, and when every part of the horizontal sails has the same distance from the axis of motion as the corresponding parts of the vertical sails. But if the horizontal sails have the position AI, EG, in Plate CCCLXIV. Fig. 11. instead of the position CA $d\,m$, CD $o\,n$, their power will be greatly increased, though the quantity of surface is the same, because the part CP 3 m being transferred to BI 3 d, has much more power to turn the sails.

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* See *Repertory of Arts*, vol. vi.

† Ferguson's *Lectures*, vol. ii. p. 291.

For farther information on the subject of Windmills, See Parent, *Mem. Acad. Par.* Belidor, *Architecture Hydraulique*, tom. ii. b. xiv. p. 23—41. Wolfii *Opera Math.* tom. i. p. 680. La Hire, *Mem. Acad.* par. ix. p. 96. Euler, *Nov. Com. Petrop.* vol. vi. p. 75. Euler, *Mem. Acad. Berl.* 1766, vol. xii. p. 164. (An abstract of Euler's investigations will be found in *Ferguson's Lectures Appendix.* vol. ii. p. 272, &c.) Lambert, *Mem. Acad. Berl.* 1775, p. 92. Stedman, *Phil. Trans* 1777, p. 493. Maclaurin's *Fluxions*, § 910—914 Coulomb, *Mem. Acad. Par.* 1781 p. 65. Smeaton, *Phil. Trans.* 1759, p. 100. Gower, *Phil. Mag.* vol. iv. p. 174. Beatson *On Vertical and Horizontal Windmills*, Lond. 1798. Byewater, *Repertory of Arts*, vol. vi. New Series Verrier *On Bailey's Machines*, vol ii. p. 47; and Ferguson's *Lectures on Mechanics*, &c. vol. ii. p. 258—288.

On the subject of Horizontal Windmills, see Hooke. *Phil. Collections*, No. 3. p. 61. Couplet, *Machines approuv.* i. p. 105. Duquet, *Id.* i. p. 107. Gallon, *Id.* vi. p. 75. Dubost, *Id.* vii. p. 117. Emerson's *Mechanics.* Smeaton, *Phil. Trans.* 1759, p. 100. Bourrier, *Mem. Acad. Par.* ii. p. 19. Maiziere in Rozier's *Introd.* i. p. 306. Gilpin, *American Transactions*, vol. i. p. 405. Wiseman, *Repertory of Arts*, vol. iv. p. 12. Maunsell, *Id.* vol. vii. p. 6. Beatson in *Repertory*, vol. ii. p. 13, Second Series. Brayshay, *Repertory*, vol. ii.

SECT. III. *General Comparison of the Effects of Mechanical Agents.*

FROM the great improvements which are constantly taking place in all kinds of machinery, it is by no means easy to state any general comparison between the various agents which are employed as the first movers of machinery. The following are the results obtained by Mr. Fenwick.

When a horse raises coals by a wheel and axle, and moves at the rate of about two miles an hour, Mr. Fenwick found that he could continue at work 12 hours each day, $2\frac{1}{2}$ hours being spent in short intervals of rest, when he raised 1000 pounds avoirdupois through the height of *thirteen* feet in *a minute*. Mr. Fenwick likewise found, that 230 ale gallons of water delivered every minute on an overshot water-wheel 10 feet in diameter;—that a common steam-engine with a cylinder *eight* inches in diameter, and an improved engine with a cylinder 6.12 inches in diameter, will do the same work as *one horse*, or raise 1000 lbs. avoirdupois through the height of *thirteen feet* in a minute. Upon these data he constructed the following Table, which we have enlarged by adding the 6th, 7th, and 8th columns.

Table shewing the Relative Strength of Overshot Wheels, Steam Engines, Horses, Men, and Wind-mills of different kinds.

Number of Ale Gallons delivered on an overshot wheel 10 feet in diameter every minute.	Diameter of the cylinder in the Common Steam Engine in inches.	Diameter of the cylinder in the Improved Steam Engine in inches.	Number of Horses working 12 hours per day, and moving at the rate of 2 miles per hour.	Number of men working 12 hours a-day.	Radius of Dutch sails in their common position in feet.	Radius of Dutch sails in their best position in feet.	Radius of Mr Smeaton' enlarged Sail in feet.	Height to which these different powers will raise 1000 lbs. avoirdupois in a minute.
230	8.	6.12	1	5	21.24	17.89	15.65	13
390	9.5	7.8	2	10	30.04	25.30	22.13	26
528	10.5	8.2	3	15	36.80	30.98	27.11	39
660	11.5	8.8	4	20	42.48	35.78	31.30	52
790	12.5	9.35	5	25	47.50	40 00	35.00	65
970	14.	10.55	6	30	52.03	43.82	38.34	78
1170	15.4	11 75	7	35	56.90	47.33	41.41	90
1350	16.8	12 8	8	40	60.09	50 60	44.27	104
1445	17.3	13 6	9	45	63.73	53.66	46.96	117
1584	18.5	14.2	10	50	67.17	56.57	49.50	130
1740	19.4	14 8	11	55	70.46	59.33	51.91	143
1900	20.2	15.2	12	60	73.59	61.97	54.22	156
2100	21.	16.2	13	65	76.59	64.5	56.43	169
2300	22.	17.	14	70	79.49	66.94	58.57	182
2500	23.1	17 8	15	75	82.27	69.28	60.62	195
2686	23.9	18 3	16	80	84 97	71.55	62.61	208
2870	24.7	19.	17	85	87.07	73.82	64.16	221
3055	25.5	19.6	18	90	90.13	75.90	67.41	234
3240	26.2	20.1	19	95	92.60	77.98	68.23	247
3420	26.	20.7	20	100	95.00	80.00	70.00	260
3750	28 5	22.2	22	110	99 64	83.90	73.42	286
4000	29.8	23.	24	120	104.06	87.63	76 68	312
4460	31.1	23.9	26	130	108.32	91.22	79.81	338
4850	32.4	24.7	28	140	112.20	94.66	82.82	364
5250	33.6	25.5	30	150	116.35	97.98	85.73	390

It appears from Mr. Smeaton's experiments, that Dutch sails, in their *common position*, (that is, when their extremities are parallel to the plane in which they move) having a radius of *nine feet and a half*;—that Dutch sails, in their *best position*, (that is, when their extremities make an angle of 7° with the plane of their motion) having a radius of *eight feet*;—and that his own *enlarged sails*, (which are the Dutch sails in their best position, enlarged at their extremities) with a radius of *seven feet*,—perform the same work as *one man*, or *one-fifth of the work of a horse*.

The following statement of the power of Mr. Watt's engines is given in his own words. "The burning of one bushel of good Newcastle or Swansea coals in Mr. Watt's reciprocating engines, working more or less expansively, was found, by the accounts kept at the Cornish mines, to raise from 24 to 32 millions of pounds of water one foot high; the greater or less effect depending upon the state of the engine, its size, and rate of working, and upon the quality of the coal.

"In engines upon the rotative double construction, one having a cylinder of $31\frac{1}{2}$ inches diameter, and making $17\frac{1}{2}$ strokes of seven feet long per minute, called 40 horses power, meaning the constant exertion of 40 horses (for which purpose, supposing the work to go on night and day, three relays, or at least 120 horses must be kept,) consumed about four bushels of good Newcastle coal per hour, or 400 weight of good Wednesbury coal. A rotative double engine, with a cylinder of $33\frac{3}{4}$ inches in diameter, making $21\frac{1}{2}$ strokes of five feet long per minute, was called 20 horses power; and an engine with a cylinder of $17\frac{1}{2}$ inches diameter, making 25 strokes of four feet long per minute, was called 10 horses power; and the consumption of coals by these was nearly proportional to that of the 40 horses power."

CHAP. II.

ON THE FORM OF THE ACTING PARTS OF MACHINERY, NAMELY, THE TEETH OF WHEELS, AND THE WIPERS OF STAMPERS.

In conveying the power of the first mover from the impelled to the working point of a machine, the various simple mechanical powers which are combined in the formation of the machinery, must in general have the motion of the one transmitted to the other by means of wheels and pinions. It becomes therefore a point of great importance, to determine the form which must be given to the acting faces of the teeth, in order that one wheel may drive the other with an uniform force.

In this investigation the largest of the two wheels M, N, viz. M, (Plate CCCLXIV. Fig. 18.) is called the *wheel*, and the smaller, N, the pinion. The acting parts of the wheel are called *teeth*, and the acting parts of the pinions *leaves*. When the pinions have the form shewn in Fig. 7. Plate CCCLXI. they are called *lanterns*, and the cylindrical teeth *trundles* or *spindles*.

The line BF joining the centres B and F of the wheel and pinion, is called the *line of centres ;* and when this line of centres is divided into two parts BA, FA, which are to one another as the number of leaves in the pinion is to the number of teeth in the wheel, FA is called the *primitive radius* of the wheel, and BA the *primitive radius* of the pinion; while the lines F f and B b are called the *true radii* of the wheel and pinion. The circles XA, RA, are called the *primitive circumferences*, or *pitch lines.*

I. *If the acting faces of the teeth of a wheel are epicycloids, whose generating circle has the same radius as the primitive radius of the pinion, and whose base has the same radius as the primitive radius of the wheel; and if these teeth drive the pinion, by acting upon infinitely small pins in its circumference, the motion of the wheel and pinion will be uniform.*

Let $m\,m'\,m''$ (Plate CCCLXIV. Fig. 19.) be the primitive circumference of the wheel M, and $a\ b\ c$ that of the pinion N. Let $m\,n$, $m'\,n'$, $m''\,n''$ be equidistant epicycloidal lines generated by the revolution of the wheel N upon M, or successive positions of the curve line $m\,n$ and a, b, c, small equidistant pins in the rim of the pinion, or successive position of the pin a, by which the epicycloidal lines were generated. Now, since the epicycloids $m\,n$, $m'\,n'$, and $m''\,n''$ are formed by the circumference $c\ b\ a$ rolling over $m''\,m'\,m$, the arch $a\,b$ must be equal to $m\,m$, and the arch $a\,c$ to $m\,m''$; for as the epicycloids $m\,n$, $m'\,n'$, $m''\,n''$, are described by the points a, b, c, every point of the arch $a\,b$ must have been in contact with every corresponding point of $m\,m'$; and therefore $a\,b = m\,m$, and. for the same reason, $a\,c = m\,m''$. Hence, if the pinion N is driven by the wheel M, by means of the epicycloidal teeth $m\,n$, &c. acting upon the pins, a, b, c, &c. each of them will describe in the same time arcs of equal length, and therefore their motion will be uniform.

II. *If the acting faces of the teeth of a wheel are epicycloids, whose generating circle is of any magnitude whatever, and whose base is the convex circumference of the wheel, and if the acting faces of the leaves of the pinion are epicycloids, described by the same generating circle, and whose base is the concave circumference of the pinion, the motion of the wheel and pinion will be uniform.*

Let $m\,m'\,m''$, (Plate CCCLXIV Fig. 20.) be the convex circumference of the wheel M, and $m\ n$ an epicycloid generated by a circle of any diameter B$'m$ rolling upon it; and let $a\ v$ be another epicycloid formed by the same circle B$'m$, rolling upon the concave circumference $c\ b\ a$ of the pinion N, then, if the teeth of the wheel have the acting faces of the form $m\,n$, and the leaves of the pinion their acting faces of the form $a\,v$, the one will drive the other uniformly. Let the epicycloids $m\ n$, $a\ v$, be in the positions $m'\,n'$, $b\ v'$, then, since in the formation of the epicycloids $m'\,n'$, $b\ v'$, the two bases coincide at m, the two epicycloids must also coincide and touch each other at the point d in the circle B m, so taken that $a\,d = m\,m'$. But $a\,b$ is also equal to $a\,d$, as the epicycloid $b\ v'$ is formed by the developement of $a\,d$ from $b\,a$; hence $a\ b = m\,m'$; that is, the wheel and pinion will describe arcs of equal length in the same time, and therefore their motion will be uniform.

III. *If the acting faces of the teeth of a wheel are epicycloids, whose generating circle has a radius equal to half the radius of the pinion, and a base of the same radius as the wheel, and if the acting faces of the leaves of the pinion are straight lines directed to the centre of the pinion, the motion of the wheel and pinion will be uniform.*

This mode of action, which we have represented in Plate CCCLXIV. Fig. 21, is a particular case of the preceding mode; for when the radius of the generating circle is one half of the radius of the concave base on which it revolves, the *interior epicycloid* $a\ v$, (Plate CCCLXIV. Fig. 13.) which it describes, then becomes a straight line. (See Art. EPICYCLOID. and Plate CCLIII. Fig. 14.) The demonstration is therefore the very same as in Case II.

IV. *If a wheel* M, (Plate CCCLXV. Fig. 1.) *drives a wheel* N, *by means of teeth* m n, m′ n′, *acting upon the leaves* aa′, bb′, *which are respectively involutes of circles* mm′, ab, *to which any line* CD, *passing through* A, *is a common tangent, the motion of the wheel and pinion will be uniform.*

Having drawn through A any right line CD, let fall upon it from the points F and B the perpendiculars FC and BD, and with the radii FC, BD describe the circles C $m'\ m$, D $a\ b$; then if we form the involutes $m\ n$, $a\ d'$, by evolving CA from the circumferences C m and D a, it is obvious that they will touch one another at the point A, and that the common tangent CD will be perpendicular to both at that point. Let $m\,n$ have the position $m'\ n'$, when $a\ a'$ has the position $b\ b'$, then it is manifest that the point A′, in which they touch one another, will always be in the straight line CD; for A′, for instance, will be in both the involutes formed by evolving CA′, DA′ from the arches C m'. D b. Now, since
$m\ m' = \mathrm{C}\,m - \mathrm{C}\,m' = \mathrm{CA} - \mathrm{CA}' = \mathrm{AA}'$, and

$$a\,b = \mathrm{D}\,b - \mathrm{D}\,a = \mathrm{DA}' - \mathrm{DA} = \mathrm{AA}',$$

we have $m\,m = a\,b$; that is, the wheel and pinion will describe arcs of equal length in the same time.

On the Teeth of Rackwork.

V. *If the teeth of a rack, as shewn in* Plates CXXXV. Fig. 1. and CXXXVII. Fig 11. *drive a toothed wheel, then, when the acting faces of a rack are cycloids, whose generating circle has the same radius as the pinion, and when their teeth drive the pinion by acting upon infinitely small pins placed in its circumference, the motion of both will be uniform.*

As this is a case of Art. I. where the radius of the wheel is infinitely great, and where the epicycloids pass into the cycloids, it does not require any farther demonstration.

VI. *If the acting faces of the teeth of the rack are cycloids, whose generating circle has a radius equal to half the radius of the wheel, and they drive the wheel by acting upon rectilineal teeth, which are a continuation of the radii, the motion of both will be uniform.*

As this is a case of Art. III. where the radius of the wheel, or the base of the epicycloids, is infinitely great, it requires no demonstration.

VII. *When the teeth of a wheel driving a rack have their acting faces formed of the involutes of a circle, having the same radius as the pinion, and drive the rack by acting upon infinitely small pins fixed in its rectilineal edge, the motion will be uniform.*

As this is a case of Art. I. where the radius of the pinion is infinitely great, and where the *epicycloid* becomes an *involute*, from the radius of its generating circle becoming infinitely great, it requires no demonstration.*

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* An involute formed by unfolding a thread from a cylindrical surface, is the same as if it were formed by any point in the edge of a straight ruler rolling over the cylindrical surface. See Ferguson's *Lectures*, vol. iv. Appendix, p. 226, 227.

On the form of the Teeth for driving Lanterns.

VIII. *If the acting faces of the teeth of a wheel are curves drawn parallel to an epicycloid, formed by the revolution of a circle equal to the lantern upon the wheel as a base, so that the distance between the epicycloid and the curve is equal to the radius of the spindles, this wheel will drive the spindles with an uniform motion.*

Let the figure of the teeth of the wheel M, (Plate CCCLXV Fig. 2.) whose primitive radius is F m, be required, in order to drive uniformly the lantern N, whose primitive radius is B m. Let $p\,m$ be the radius of the spindles, then with a generating circle, whose radius is B m, and on a base, whose radius is F m, describe the exterior epicycloid $m\,n$. This epicycloid would be the proper form of the teeth, if the spindles $p\,m$ were infinitely small. (See Art. I.) Upon any number of points in the epicycloid $m\,n$, as centres, with $p\,m$, the semidiameter of the spindles as a radius, describe arches of circles, the curve $m'n'$, drawn so as to touch all these circles will be parallel to the epicycloid, and will be the form of the teeth required. The same form must be given to the teeth when they are placed on the concave or interior side of the wheel, and drive the lantern in the inside of the wheel. The epicycloids are of course in that case interior ones, as the generating circle rolls upon the concave side of the bore.

Since the epicycloid $m\,n$ drives the infinitely small spindle at m uniformly by Art. I. so that m is at μ when the spindle is at a, $a\,m = m\,\mu$, it follows that the equidistant curve $m'\,n'$ will drive the spindle $p\,m$ uniformly. For as the point where $m'\,n'$ touches the spindle must always be distant from m by the radius of the spindle, the point m' will want a quantity $= m\,p$ of the point μ, and the corresponding point of the spindle which the point m' touches will want the same quantity $m\,p$ of the point a; and, therefore, since $a\,m = \mu\,m$, $a\,m - m\,p = \mu\,m - m\,p$; that is, the wheel and lantern will move uniformly.

If it is required, that the teeth do not act upon the spindles till the former reach the line of centres FB, the curve $m'\,n'$ should not touch the spindles till the point m' has arrived at m. The tooth $m'\,n'$, therefore, will begin to act upon the spindle at the point o, where the primitive circumference of the lantern cuts the circumference of the spindle. The unshaded parts, therefore, of the spindles, might be cut away as superfluous; but as it is obviously better that they retain their cylindrical form, the hollows between the teeth of the wheel should be arches of a circle described by a radius a little greater than $m\,p$.

On the Form of the Wipers of Stampers, and the lifting Cogs or Cams of Forge Hammers.

IX. *If the wipers for raising stampers have their acting faces on the involutes of a circle, whose radius is that of the wheel upon which they are to be fixed, and if they elevate the stamper, by acting upon a plain surface perpendicular to the vertical direction in which the stamper rises, the motion will be uniform.*

This kind of action is shewn in Plate CCCLXV. Fig. 3. where M is the wheel furnished with wipers, and N the stamper. The curve $b\,c$ of the stamper is an involute, formed by evolving the arch $a\,b$, which must always be equal to the height $n\,n'$ through which the stamper is to be raised. This is the same case as that in Art. VII.

X. *If the wiper is to raise the stamper in the manner shewn in* Fig. 4, *it will be raised uniformly if the acting face of the wipers has the form of the spiral of Archimedes.*

Let it be required to raise the weight MN by its extremity o uniformly through the height O e, in the same time that the wheel moves through one-fourth of its circumference. Having divided the quadrant OH into any number of equal parts O m, $m\,n$, &c. and O e into the same number O b, $b\,c$, &c. draw the indefinite lines AB, AC, and through the points m, n, &c. make AB = A b, AC = A c, &c. and through the points O, B, C, &c. draw the curve OBCDE, which is a part of the spiral of Archimedes. When the point m has reached O, the extremity o of the weight will have been raised to b, because AB = A b; and, for the same reason, the extremity o will have arrived at the points c, d, e, when the points n, p, H, have come to O. Hence the motion is uniform.

If it is desired to raise the weight with an accelerated or a retarded motion, we have only to divide the line O e according to the law of acceleration and retardation, and form the curve OBCDE as formerly.

XI. *If the weight is to move round a centre, and rise in the same plane as that in which the wheel moves, the acting faces of the wipers must be formed in the following manner.*

Let AB (Plate CCCLXV. Fig. 5.) be a lever lying horizontally, which is to be raised uniformly through the arch BC into the position A, by means of the wheel BFH, furnished with the wing BNOP, that acts upon the extremity C of the lever; and let it be required to raise it through BC, in the same time that the wheel BFH moves through one-half of its circumference; that is, while the point M moves to B, in the direction MFB. Divide the chord CB into any number of equal parts, the more the better, in the points 1, 2, 3, and draw the lines 1 a, 2 b, 3 c, &c. parallel to AB, or a horizontal line passing through the point B, and meeting the arch CB in the points a, b, c. Draw the lines CD, a D, b D, c D, and BD, cutting the circle BFH in the points m, n, o, p.

Having drawn the diameter BM, divide the semicircle BFM into as many equal parts as the chord CB, in the points q, s, u. Take B m, and set it from q to r: take B n, and set it from s to t: take B o, and set it from u to v: and lastly, set B p from M to E. Through the points r, t, v, E, draw the indefinite lines DN, DO, DP, DQ, and make DN equal to D c; DO equal to D b; DP equal to D a; and DQ equal to DC. Then, through the points Q, P, O, N, B, draw the spiral B, N, O, P, Q, which will be the proper form for the wing of the wheel, when it moves in the direction EMB.

That the spiral BNO will raise the lever AC with an uniform motion, by acting upon its extremity C, will appear from the slightest attention to the construction of the figure.

It is evident, that when the point q arrives at B, the point r will be in m, because B m is equal to $q\,r$, and the point N will be at c, because DN is equal to D c; the extremity of the lever, therefore, will be found in the point c having moved through B c. In like manner, when the point s has arrived at B, the point t will be at n, and the point o in b, where the extremity of the lever will now be found; and so on with the rest, till the point M has arrived at B: the point E will then be in p, and the point Q in C; so that the lever will now have the position AC, having moved through the equal heights B c, c b, b a, a C,* in the same time that the power has moved through the equal spaces q B, s q, u s, M u. The lever therefore has been raised uniformly, the ratio between the velocity of the power, and that of the weight remaining always the same.

If the wheel D turns in a contrary direction, according to the letters MHB, we must divide the semicircle BHEM into as many equal parts as the chord CB, viz. in the points, e, g, i. Then having set the arch B m from e to d, the arch B n from g to f, and the rest in a similar manner, draw through the points d, f, h, E, the indefinite lines DR, DS, DT, DQ: make DR equal to D c; DS equal to D b; DT equal to D a, and DQ equal to DC; and through the points B, R, S, T, Q, describe the spiral BRSTQ, which will be the proper form for the wing, when the wheel turns in the direction MHB. For, when the point e arrives at B, the point d will be in m, and R in c, where the extremity of the lever will now be found, having moved through B c in the same time that the power or wheel has moved through the division e B. In the same manner it may be shewn, that the lever will rise through the equal heights c b, b a, a C, in the same time that the power moves through the corresponding spaces eg, gi, i M. The motion of the lever, therefore, and also that of the power, are always uniform. Of all the positions that can be given to the point B, the most disadvantageous are those which are nearest the points F, H, and the most advantageous position is when the chord BC is vertical, and passes, when prolonged, through D, the centre of the circle. In this particular case the two curves have equal bases, though they differ a little in point of curvature. The farther that the centre A is distant, the nearer do these curves resemble each other, and if it were infinitely distant, they would be exactly similar, and would be the spirals of Archimedes; or the extremity C would in this case rise perpendicularly.

The reader will easily perceive that 4, 6, or 8 wings may be placed upon the circumference of the circle, and may be formed by dividing into the same number of equal parts as the chord BC, $\frac{1}{4}$, $\frac{1}{6}$ or $\frac{1}{8}$, of the circumference, instead of the semicircle BFM.

XII. *If the weight is to move round a centre, and in the same plane as that in which the wiper moves, it may be done by a constant radius acting upon a curvilineal surface on the body to be raised, which may be found in the following manner* †

Let it be required to raise the lever AB (Plate CCCLXV. Fig 6) through the arch BC, into the position AC, by a uniform motion, by means of the arm or constant radius DE moving upon D as a centre, in the same time that the extremity E describes the arch E e F. From the point C draw CH at right angles to AB, and divide it into any number of equal parts, suppose three, in the points 1, 2; and through the points 1, 2, draw 1 a, 2 b, parallel to the horizontal line AB, cutting the arch CB in the points a, b through which draw a A, b A. Upon D as a centre, with the distance DE, describe the arch E i e F; and upon A as a centre, with the distance AD, describe the arch e OD, cutting the arch E i e F in the point e. Divide the arches E i e, and F s e, each into the same number of equal parts as the perpendicular c H, in the points k i s m, and, through these points, about the centre A, describe the arches k z, i g, q r, m n. Take z x, and set it from k to l, and take g f, and set it from i to h. Take r q also, and set it from s to t, and set n m from o to p, and d c from e to O. Then through the points E, l, h, O, and O, t, p, F, draw the two curves E l h O, and O t p F, which will be the proper form that must be given to the arm of the lever. If the handle DE moves from E towards F, the curve EO must be used; but if in the contrary direction, we must employ the curve OF.

It is evident, that when the extremity E of the handle DE has run through the arch E k, or rather E l, the point l will be in k, and the point z in x, because x z is equal to k l, and the lever will have the position A b. For the same reason, when the extremity E of the handle has arrived at i, the point h will be in i, and the point g in f, and the lever will be raised to the position A a. Thus it appears, that the motion of the power and the weight are always proportional. When a roller is fixed at E a curve parallel to EO or OF must be drawn as formerly.

On the Teeth of Bevelled or Conical Wheels.

In bevelled or conical wheels, a portion of a fluted or toothed cone is made to drive a portion of another fluted or toothed cone, as shewn in Figs. 7 and 8 of Plate CCCLXV and also in Plates LXXVIII. Fig. 3. Plate CCXXXIX. Fig. 2 at MN and IK. Plate CCXL. Fig. 8, at e, d, and Plate CCLXXXI Fig. 7, at a and L, for the purpose of changing the direction of any motion into any other direction, inclined at any angle to the first direction.

In order to determine the relative size of the wheels for changing a motion into a direction inclined 30°, for example, to its first direction, and in which the new axle shall move with four times the velocity of the first. Let AB (Plate CCCLXV. Fig. 9.) be the original direction of the motion through any point O; draw COD, inclined 30°, to AB; then, since the axle CD is to move four times more rapidly than AB, the wheel which it carries must have one-fourth the number of teeth, and one-fourth the diameter. Draw c d at any convenient distance from CD, and parallel to it, and draw a b parallel to AB, so that A a=B b=4 C=4 D d, and join the points of intersection i and O. Draw O m, so that the angle BO m=BO i, and draw O n, so that DO n=DO i, and these lines will mark out the size and situation of the cones of which the wheels are to be portions. By attending to the preceding construction, it is obvious that it is nothing more than to divide the angle BOD into two angles, whose sines are to one another as the number of the revolutions of the one wheel is to the number of revolutions of the other, and as Mr. Simpson has shewn, (*Select Exercises*, p. 158.) 2 sin. ½ B o [illegible]

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* The arches B c, c b, &c. are not equal; but the perpendiculars let fall from the points c a, b, &c. upon the horizontal lines, passing through a, b, &c. are equal, being proportional to the equal lines c I, I 2, Eucl. VI. 2. Had it been required to raise the lever through equal arches, instead of equal heights in equal times, then the arch B c, instead of its chord, would have been divided into equal parts.

† For an account of the method of forming the wipers, when the weight rises in a plane at right angles to that in which the wipers move, see *Ferguson's Lectures*, Vol. II. *App.* p. 253.

$=2 \sin. \frac{1}{2} \mathrm{BOD} \times \frac{m}{m \times n}$, m and n representing the number of revolutions of the wheels.

If we suppose the primitive circumference of the pinion N, or the circumference of the base of the cone CN, to roll upon the primitive circumference of the wheel M, or the circumference of the base of the cone CM, any point will obviously describe a curve; and as the point N is always at the same distance NC from the centre C, it must be always in the surface of a sphere, whose centre is C, and therefore the curve which it describes will also be in the surface of a sphere, and has hence been called a *spherical epicycloid.*

XIII. *If the acting faces of the teeth of the wheel* M *have the form of a spherical epicycloid, whose generating circle is the primitive circumference of the pinion, and whose base is the primitive circumference of the wheel, and if they drive the pinion* N *by acting upon infinitely small pins in its circumference at* N, *the motion of both will be uniform.*

Let $a\,b$, Fig. 10. Plate CCCLXV. be part of the primitive circumference of the pinion, whose axis is AN, and $m\,m'$ part of the primitive circumference of the wheel, whose axis is AM. Let $m\,n$ be a portion of a spherical epicycloid formed by the generating circle $a\,b$ rolling upon the base $m\,m'$, and let it act upon the pin a, and have the position $m'\,n'$, when the pin a has reached b. Had the point b been placed on m', and the generating circle rolled from m' to m, the point b would have formed the spherical epicycloid $m'\,n'$, and the arch $b\,m$ would have been equal to $m'\,m$; but as the tooth $m\,n$ has driven a to b in the same time that m has advanced to m', and as $a\,b = m'\,m$, the wheel M has driven the pinion N uniformly.

XIV. *If the acting faces of the teeth of the wheel* M *have the form of spherical epicycloids, whose generating arch has a radius equal to half the primitive radius of the pinion, and whose base is the primitive circumference of the wheel, and if they drive the pinion* N, *by acting upon rectilineal leaves directed to its centre, the motion will be uniform.*

Let N m, (Plate CCCLXV. Fig. 11.) be now the radius of pinion, and $m\,n$ a sperical epicycloid, whose generating circle has its diameter N m equal to the radius N m of the pinion $m\,o$. Let N m and N o be the rectilineal faces of its leaves directed to N, and let the leaf N m be driven into N o, when the tooth $m\,n$ has reached $m'\,n'$. Now the arc $m\,p$ is equal to $m\,m'$, because $m'\,n'$ is a spherical epicycloid formed by the point p; and since the straight line N o is formed by the circle $m\,p$, revolving on the concave side of $m\,o$, (see Art. III.) the point p must have coincided with o, and therefore the arc $m\,o$ is equal to $m\,p$, and therefore $m\,o = m\,m'$; and consequently the wheel and pinion have moved through equal spaces in equal times.

XV. *If a bevelled wheel drives a conical lantern with conical spindles, it will be done uniformly when the acting faces of the teeth of the bevelled wheel have the form of a curve drawn parallel to the spherical epicycloid in* Art. XIII. *and distant from it by the radius of the spindle.*

This is demonstrated in the same way as in Art. VIII. and the curve is drawn in the manner there described.

It is obvious, that in forming the teeth of bevelled wheels, the external spherical section a (Plate CCCLXV. Fig. 8.) must be different from the internal spherical section b, the spherical epicycloid at b being generated by a circle, which is the circumference of the conical pinion at n, and the base being the circumference of the conical wheel at b. When one of these spherical epicycloids is given, the other may be found by drawing straight lines from C to every point of the one which is given, and these lines will pass through the corresponding points of the other at all distances from C.

In the preceding observations, we have given a general view of the methods of shaping the acting faces of the communicating parts of machines, which is all that we can attempt to do in a limited article like the present. That the engineer, however, may have some idea of the subordinate details to which he must attend, in the actual construction of the teeth of wheels, we shall point them out in the case of an ordinary wheel and pinion.

Let FA, BA, (Plate CCCLXV. Fig. 12.) be the primitive radii of the wheel and pinion, which must always be in the ratio of the number of teeth in the one to the number of teeth in the other, and these again as the velocities of the axles upon which they are fixed. With these radii describe the primitive circumferences C′CDA, $c'\,c\,d\,a$. As the distances between the teeth should always be a little greater than the thickness of the teeth, and as the number of the teeth must always be a whole number, we shall have the thickness of the teeth.

In the wheel,

$$\mathrm{T} = \frac{2 \times 3.1416\ \mathrm{FA}}{\mathrm{N}} - \mathrm{D}$$

$$\mathrm{D} = \frac{2 \times 3.1416\ \mathrm{FA}}{\mathrm{N}} - \mathrm{T}$$

In the pinion,

$$t = \frac{2 \times 3.1416\ \mathrm{BA}}{n} - d$$

$$d = \frac{2 \times 3.1416\ \mathrm{BA}}{n} - t$$

where T, t = thickness CD of the teeth,
D, d = distance C′C′ between the teeth,
N, n = the number of teeth in the wheel and pinion.

Upon the radius BA describe the circle BPA, with which, as a generating circle rolling upon C′CD as a base, describe the epicycloid CE, which will be the form of that part of the tooth. The point E, where the epicycloid CE cuts the same epicycloid DE reversed, determines the summit E of each tooth. As the leaves of the pinion must have their epicycloids $d\,e$, $c\,e$, formed by a generating circle, whose diameter is F A, rolling upon a base whose radius is BA, these epicycloids must, by Art. III. act upon rectilineal or plane surfaces, in order to give a uniform motion. Hence the parts CM, DN of the wheel, and $c\,m$, $d\,m$ of the pinion, must be straight lines directed to the centres F, B. In order to determine the points m, n, describe a circle EE from F, as a centre passing through the summits of the teeth, and let P be the point where this circle cuts the primitive circumference $c'\,c\,d$, and Q the point where it cuts the generating circle BQA, and we shall have $c\,m = d\,n = \mathrm{BP} - \mathrm{BQ}$; or a circle BQR, described with the radius BQ, will mark out all the points m, n for every tooth of the pinion, and therefore determine the size of what has been called the *flanks* $c\,m$, $d\,n$ of the teeth. The epicycloidal face AG of the tooth, in conducting the flank AR of the pinion into QA, passes from the position AG to the position QQ′, so that AQ=AQ′, and then the radius BQA′ will (by Art. III.) be a tangent to the point Q. The tooth will still act upon the flank beyond this position, and will finally quit it at the point P. When the flank BA has arrived at BA′, another tooth of the wheel should begin to act upon another flank of the pinion.

The size of the flanks CM, DN of the wheel FA, are determined in the very same manner.

The form of the curve $m\,s$ must obviously be the line which the point G of the tooth AG describes upon the plane of the wheel B, when both are in motion. This curve may be shewn to be a prolate epicycloid, whose generating circle has a radius equal to FA, and a base whose radius is BA. In like manner, the curve MN will be a prolate epicycloid, whose generating circle has BA for its radius, and whose base is a circle, with a radius FA.* The application of this curve to the hollows of the teeth, is not of any importance with regard to their mutual action. It only determines the path of the point of the teeth; and, in this way, we know exactly how great a hollow to cut out, in order that the teeth may have the greatest possible degree of strength, having no more cut from their base than is absolutely necessary.

In the preceding observations, it has been supposed that the teeth of the one wheel does not begin to act upon the teeth of the other wheel till they arrive at the line of centres, and that the action is all carried on beyond that line. It is obvious, however, that the action may commence before the teeth arrive at the line of centres, and may be completed when they reach that line; or that the action may be performed in both ways, both before the teeth have reached the line of centres, and after they have passed it.

The first of these methods is undoubtedly the best, and is therefore generally adopted. In the second method the friction is increased, and the dust which falls upon the teeth is pushed into the hollows between them. The third mode unites the advantages and disadvantages of the other two.

M. Camus has shewn,† that a pinion of *seven* leaves cannot be impelled easily *behind* the line of centres by a wheel of any number of teeth whatever, and therefore the action must be carried on partly before and partly behind that line. He has also shown the same thing of a pinion of eight and nine leaves. A pinion of ten leaves may, however, be moved by a wheel of 72 teeth beyond the line of centres, provided the distance between the teeth is a little less than the breadth of the teeth; for, if these spaces were equal, the leaves of the pinion would necessarily be caught by the teeth of the wheel before they reach the line of centres.

We shall now conclude this chapter with some excellent remarks by Dr. Thomas Young on the teeth of wheels.‡

"The magnitude of the friction has usually been estimated by the relative velocity of the surfaces concerned; a mode of calculation, which, as I have observed in my lecture on machinery, is only so far correct, as it shows the comparative effect of a given friction in retarding the machine. But, in fact, the primitive friction itself is liable to variation according to the obliquity of the surfaces; for since the friction is nearly proportional to the mutual pressure, it will be greater or less, as the direction of these surfaces is more or less inclined to the radii, the force of rotation being supposed to be given: and, what is of still more immediate importance to the resolution of the difficulty in question, the direction of the force by which the one wheel acts on the other, is not to be considered as perpendicular to the surface of the teeth, but as oblique to it, being so situated as to oppose the joint result of the direct resistance and the friction; that is, as being inclined to the surface in a certain constant angle, which a late anonymous writer has called the angle of repose, and which is equal to the inclination of a plane, on which one of the substances concerned would begin to slide on the other by its gravitation.

Let the tooth A impel the tooth B with the given force AC, perpendicular to the common surface of the teeth; make CAD equal to the angle of repose, then the force must act in the direction AD, and, making CD parallel to the radius AE, AD will be the actual pressure: then drawing DF parallel to the radius AG, AF will be the effective force in the direction AC, and FC will be the loss by friction. Again, if B impel A, the angle of repose must lie on the other side of AC, and CH must be parallel to AG, and HI to AE, and the friction in this case will be IC, which is obviously less than FC.

Hence we may easily calculate the magnitude of the resistance FC or IC produced by friction, calling the force AC unity; for CD becomes $\frac{s.\mathrm{CAD}}{s.\mathrm{ADC}}$, and $\mathrm{FC}=\mathrm{CD}\,\frac{s.\mathrm{CDF}}{s.\mathrm{CFD}}=\frac{s.\mathrm{CAD}}{s.\mathrm{ADC}}.\frac{s.\mathrm{CDF}}{s.\mathrm{CFD}}=\frac{s.\mathrm{CAD}}{s.(\mathrm{CAE}+\mathrm{CAD})}.\frac{s.\mathrm{GAE}}{s.\mathrm{GAC}}$; and in the same manner $\mathrm{IC}=\frac{s.\mathrm{CAH}}{s.\mathrm{AHC}}.\frac{s.\mathrm{CHI}}{s.\mathrm{CIH}}=\frac{s.\mathrm{CAD}}{s.(\mathrm{GAC}+\mathrm{CAD})}.\frac{s.\mathrm{GAE}}{s.\mathrm{EAC}}$. Both these quantities vary ultimately as the angle formed by the radii, and vanish when the point of contact is in the line of the centres; and in this case the common theory agrees with this calculation. When CAE is always a right angle, as in the epicycloidal tooth commonly recommended, the friction FC varies, in the different positions of the teeth, as $\frac{s.\mathrm{GAE}}{s.\mathrm{GAC}}$, or as cot. GAC; that is, if AK be made constant as KL.

Since therefore it is demonstrable, that the friction is always greater in approaching the line of the centres, than at an equal distance beyond it, it must obviously be desirable that the contact should be rather after than before the passage of the teeth over that line, although it is better that it should be at a small distance before, than at a much greater distance beyond it. Hence, the impelling teeth ought to be of such a form as to accelerate the motion of the impelled a little before, and a little more after, the passage of the line of the centres, and then to retard it again, so that the next tooth may succeed to a similar operation.

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* See our article Epicycloids, where the formation of prolate and curtate cycloids is described. The very same is applicable to the epicycloid. See Hachette's *Traité Elementaire des Machines*, p. 296, for a demonstration that this curve is a prolate epicycloid.

† *Cours de Mathematique*, liv. x. § 550.

‡ These observations were published in an Essay on the Teeth of Wheels, by Robertson Buchanan, Esq. to whom they were communicated by Dr. Young.

A wheel acting on a trundle, with cylindrical staves, has in this respect an advantage over two wheels with teeth, since the curve, fitted for impelling the trundle, is adapted only to act on it beyond the line of the centres. This curve may however be formed more easily, and at the same time more advantageously, than by the method which has hitherto been recommended: for if we employ an epicycloid described by the rolling of a circle, which would just touch the internal surface of all the staves of the trundle, on the circumference of the wheel, the trundle will at first be accelerated a very little, and will then be allowed to fall back from each tooth to the succeeding one, soon after its passage over the line of the centres. The same form will also answer very well, when the trundle is to impel the wheel, although this mode of action produces a greater friction than the former.

A similar advantage may be obtained in teeth of any other form, by finishing them in such a manner as to project a very little beyond the regular outline, at the point which is intended to come into contact a little beyond the line of the centres. Such a corrected outline may be described at once, if it be required. If the tooth is to be formed into an involute of a circle, having fitted a thread or fine wire to the circumference of the wheel, find the point of contact at the instant when the end of the wire is describing the part of the tooth, which is to act at, or a little before, the line of the centres; cut off from the wheel, beyond this point, an arc equal to the distance of the centres of two adjoining teeth, and fix a pin in the tangent at the same point, that is, in the continuation of the part of the wire which is unrolled, at such a distance as just to stretch the part which is left loose by the removal of the arc: the pin thus fixed, and the remainder of the circle, will serve as bases for continuing the evolution of the wire, and the description of the tooth. The same position of the wire will show the outline of a basis proper for describing, by means of a circle rolled on it, the curve which must be substituted for the form of any epicycloidal tooth, which might have been described by causing the same circle to roll on the simple circumference of the wheel as a basis; the curved part of the tooth beginning, in this case, at the point of contact first mentioned.

If it be objected, that in such an arrangement, the equability of the motion would be lost, and a shake would be created, it may be answered, that the inequality would be utterly imperceptible in practice. But I do not know that the form thus determined would have any material advantage over teeth made as short as possible, or so cut away as not to act before the passage of the line of centres, which may easily be done in all cases, nearly in the same way as you have shewn with respect to epicycloidal teeth.

The advantage of dividing the pressure among several teeth, ought not to be purchased at the expense of an increase of friction, since the property of greater durability may be obtained, in an equal degree, by simply making the wheels thicker, without materially adding to the friction; and in fact, although the momentary pressure on each tooth may be lessened by dividing it, yet its duration is increased in the same proportion."

The following Table of pitches of wheels in actual use in mill work, was drawn up by the late Mr. Robertson Buchanan, civil engineer, and will be found of great use to the practical mechanic.

Explanation of the Table of Wheels in actual Use in Mill work.

The wheels are all reduced to what may be called one denomination.

1*st*, By proportioning all their breadths to what they should be to have the same strength, if the resistance were equal to the work of a steam engine of ten horses' power.

2*dly*, By supposing their pitch lines all brought to the same velocity of three feet per second, and proportioning their breadths accordingly. This particular velocity of three feet per second has been chosen, because it is the velocity very common for overshot wheels.

Such cases as appear to have worn too rapidly, are marked, which may tend to discover the limit in point of breadth.

Column	1	Contains the Horse's power.
	2	Pitch in inches.
	3	Breadth of teeth in inches.
	4	Number of teeth of wheel.
	5	Revolutions of wheel per minute.
	6	Diameter of wheel.
	7	Number of teeth of pinion.
	8	Revolution of pinion per minute.
	9	Diameter of pinion.
	10	Breadth proportionate to 10 horses' power, and at the present velocity.
	11	Present velocity per second in feet.
	12	Breadth in Inches proportionate to 10 horses' power, at 3 feet per second. That is, all the cases reduced to the same denomination.

Table of Pitches of Wheels in actual Use in Mill work.

Name.	Horses' power.	Pitch in inches.	Breadth of teeth in inches.	Wheel.			Pinion.			Breadth proportionate to 10 horses' power, and present velocity.	Present velocity per second in feet.	Breadth in inches proportionate to 10 horses' power, at 3 f. p. second, that is, reducing all the examples to the same denomination.	Remarks.
				Teeth.	Revolutions per minute.	Diameter.	Teeth.	Revolutions per minute.	Diameter.				
Water wheel	10	4⅛	5½									5.5	Has been 16 years at work–teeth much worn
Water wheel	30	3	10¼	304	3$\frac{1}{7}$	24	3	318.47		3.41	3.95	4.489	Has been 16 years at work. This geering was found rather too narrow for the strain, as it is wearing much faster than the rest of the wheels in the same mill.
Water wheel	15	3	6	204	4½	16..2	44	20	3..6	4.	3.8	5 06	
Water wheel	5½	3	4	207		16..5¼	50		3..11⅝	7.27	3.	7.27	The only defect in this geering, which has been 16 years at work, is the want of breadth in the spur wheel and pinion; they ought to have been 6 inches or more, as they will not last half so long as the bevel wheels and pinions connected with them.
Horse mill	1	2¼	4	91	3	6..0½	22	12.9	1..5½	40.0	.949	12 65	
Horse mill	1	2¼	4½	91	3	6..0½	20	13.13	1..4	45.0	.949	14.23	
Steam Engine, by B & W.	24	3¼	6	96	19	8..0	42	43.32	3..6	2.5	7.95	6.625	
Steam Engine, by B. & W.	46	3	8	152	17½		54	50		1.7	11.	6.2	
Steam Engine, by B. & W.	32	3	6	116	19	8..10				1.87	8.78	5.47	
Steam Engine, by B. & W.	14	3	5	64	25	5..1	29	55	2..4	3.57	6.65	7.91	
Steam Engine	20	2½	5	90	18	5..11	38	42.63	2..7	2.5	5.57	4.64	
Ditto ditto	10	2¼	5¾	77	25	4..7⅛	40	48.5	2..4⅝	5.75	6.2	11.88	This is a better pitch for the power than Q.
Ditto ditto	6	2¼	5¼	60	28	3. 7	27	62.6	1..7⅜	8.75	5.25	15.31	This wheel has wooden teeth, and has been working for three years past.
Ditto ditto	4	2¼	4¾	48	32	2..10⅕	25	61.11	1..6	11 87	4.8	18.99	Ditto ditto
Ditto ditto	12	2	4½	62		3..6			2..	3.75	8.8	11.	
Ditto ditto	10	1⅞	6	77	25	3..10	40	48.5	1..11⅛	6.	5.	10.	This pitch has been found to be too fine.
Ditto ditto	12	1⅜	3	66	44	2..8	48	60 5	1..9	2.5	5.99	4.95	

The following Table of pitches of wheels was drawn up by Mr. John Roberton, engineer, and is constructed in the manner described in the following page.

A Table of Pitches of Wheels, with the breadth and thickness of the teeth, and the corresponding number of horses' power, moving at the pitch line at the rate of three feet, of four feet, of six feet, and of eight feet per second

Pitch in inches.	Thickness of teeth in inches.	Breadth of teeth in inches.	Strength of teeth, or number of horses' power at 4 feet per second.	Horses' power at 3 feet per second.	Horses' power at 6 feet per second.	Horses' power at 8 feet per second.
3.99	1.9	7.6	27.43	20.57	41.14	54.85
3.78	1.8	7.2	23.32	17.49	34.98	46.64
3.57	1.7	6.8	19.65	14.73	29.46	39.28
3 36	1.6	6.4	16.38	12.28	24.56	32.74
3.15	1.5	6.	13.5	10.12	20.24	26.98
2.94	1.4	5.6	10.97	8.22	16.44	21.92
2.73	1.3	5.2	8.78	6.58	13.16	17.34
2.52	1.2	4.8	6.91	5.18	10.36	13.81
2.31	1.1	4.4	5.32	3.99	7.98	10.64
2 1	1.0	4.	4.0	3.0	6.0	8.0
1.89	.9	3.6	2 91	2.18	4.36	5.81
1.68	.8	3.2	2.04	1.53	3.06	3.08
1.47	.7	2 8	1.37	1.027	2.04	2.72
1.26	.6	2,4	.86	.64	1.38	1.84
1.05	.5	2.	.5	.375	.75	1.

The thickness of the teeth in each of the lines, is varied one tenth of an inch. *The breadth of the teeth* is always four times as much as their thickness. *The strength* of the teeth is ascertained *by multiplying the square of their thickness into their breadth*, taken in inches and tenths, &c. The *pitch* is found *by multiplying the thickness of the teeth by* 2. 1. The number that represents the strength of the teeth, will also represent the number of horses' power, at a velocity of about four feet per second. Thus in the table where the *pitch is* 3.15 *inches, the thickness* of the teeth 1.5 *inches*, and the *breadth* 6. *inches*, the strength is valued at 13½ *horses' power*, with a *velocity of four feet per second* at the pitch line.

We shall now conclude this chapter with a useful Table of the Radii of wheels, calculated by a very ingenious engineer, Mr. B. Donkin, millwright, Dartford, Kent. The pitch, or distance between the centres of two contiguous teeth, is taken at 2 inches; but for any other pitch the radius may be found by the following analogy. As 2 inches is to the radius in the Table, so is the new pitch to the new radius.

Table of the Radii of Wheels, from Ten to Three Hundred Teeth, the Pitch being Ten Inches, by Mr. B. Donkin.*

Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.
10	3,236	41	13,064	72	22,926	103	32,791	134	42,657	165	52.524
11	3,549	42	13,382	73	23,244	104	33,109	135	42,976	166	52,843
12	3,864	43	13,700	74	23,562	105	33,427	136	43,294	167	53,161
13	4,179	44	14,018	75	23,880	106	33,746	137	43,612	168	53,479
14	4,494	45	14,336	76	24,198	107	34,064	138	43,931	169	53,798
15	4,810	46	14,654	77	24,517	108	34,382	139	44 249	170	54,116
16	5,126	47	14,972	78	24,835	109	34,700	140	44,567	171	54,434
17	5,442	48	15,290	79	25,153	110	35,018	141	44,885	172	54,752
18	5,759	49	15,608	80	25,471	111	35,337	142	45,204	173	55,071
19	6,076	50	15,926	81	25,790	112	35,655	143	45,522	174	55,389
20	6,392	51	16,244	82	26,108	113	35,974	144	45,840	175	55,707
21	6,710	52	16,562	83	26,426	114	36,292	145	46,158	176	55,026
22	7 027	53	16.880	84	26,741	115	36,611	146	46.477	177	55,344
23	7,344	54	17,198	85	27,063	116	36,929	147	46.795	178	56,662
24	7,661	55	17,517	86	27,381	117	37,247	148	47,113	179	56,980
25	7,979	56	17,835	87	27,699	118	37,565	149	47,432	180	57,299
26	8,296	57	18.153	88	28,017	119	37,883	150	47,750	181	57,617
27	8,614	58	18,471	89	28,336	120	38,202	151	48,068	182	57,935
28	8,931	59	18,789	90	28,654	121	38,520	152	48.387	183	58,253
29	9,249	60	19,107	91	28,972	122	38.838	153	48,705	184	58,572
30	9,567	61	19,425	92	29,290	123	39.156	154	49,023	185	58,890
31	9,885	62	19,744	93	29,608	124	39,475	155	49,341	186	59,209
32	10,202	63	20,062	94	29 927	125	39,793	156	49,660	187	59,527
33	10,530	64	20,380	95	30,245	126	40,111	157	49,978	188	59 845
34	10,838	65	20,698	96	30,563	127	40.429	158	50,296	189	60,163
35	11,156	66	21.016	97	30,881	128	40,748	159	50,615	190	60,482
36	11,474	67	21,335	98	31,200	129	41,066	160	50,933	191	60,800
37	11,792	68	21.653	99	31.518	130	41,384	161	51,251	192	61,118
38	12,110	69	21,971	100	31,836	131	41,703	162	51,569	193	61,436
39	12,428	70	22,289	101	32,155	132	42,021	163	51,888	194	61,755
40	12 746	71	22.607	102	32.473	133	42,339	164	52,206	195	62,073

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* By the pitch is understood the distance between the centres of two contiguous teeth; and by the radius is understood the distance between the centre of the wheel and the centre of each tooth.

Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.	Number of Teeth.	Radius in Inches.
196	62,392	214	68,121	232	73,850	250	79,580	268	85,309	286	91,038
197	62,710	215	68,439	233	74,168	251	79,898	269	85,627	287	91,357
198	63,028	216	68,757	234	74,487	252	80,216	270	85,946	288	91,675
199	63.346	217	69,075	235	74,805	253	80,534	271	86,265	289	91,993
200	63,665	218	69,394	236	75,123	254	80,853	272	86,582	290	92,312
201	63,983	219	69,712	237	75,441	255	81,171	273	86,900	291	92,630
202	64,301	220	70.031	238	75,760	256	81,489	274	87,219	292	92,948
203	64,620	221	70,349	239	76,078	257	81,808	275	87,537	293	93,267
204	64,938	222	70,667	240	76,397	258	82,126	276	87,855	294	93,585
205	65,256	223	70,985	241	76,715	259	82,444	277	88,174	295	93,903
206	65,574	224	71,304	242	77,033	260	82,763	278	88,462	296	94,222
207	65,893	225	71,622	243	77,351	261	83,081	279	88,810	297	94,540
208	66,211	226	71,941	244	77,670	262	83,399	280	89,129	298	94,858
209	66,529	227	72,258	245	77,988	263	83,717	281	89,447	299	95,177
210	66,848	228	72,577	246	78,306	264	84,038	282	89,765	300	95,495
211	67,166	229	72.895	247	78,625	265	84,354	283	90,084		
212	67,484	230	73,214	248	78,943	266	84,673	284	90,402		
213	67,803	231	73,532	249	79,261	267	84,991	285	90,720		

For farther information on the teeth of wheels, &c. the reader is referred to Wolfii, *Oper. Math.* tom. i. p. 684. *Miscellan. Berolinens*, 1760, p. 315. De la Hire, *Traité des Epicycloides*, and *Traité de Mecanique*, Prop. 114, 115, 116. Camus, *Cours de Mathématique*, liv. x. and xi. These two books were translated into English, and published at London in 1806, with an addition taken from Imison's School of Arts, which gives erroneous rules for forming the teeth, totally different from those contained in the work to which it is prefixed. Deparcieux, *Mem. Acad. Par.* 1747, p. 243. *Euler Nov. Comment. Petrop.* 1754, 1755, tom. v. p. 299. Le Cerf, *Phil. Trans.* vol. lxviii. p. 950. Kaestner, *Comment. Gotting.* 1771, tom. xi. p. 117; 1782, tom. v. p. 9. 29. Robison's *Mechanical Philosophy*, vol. ii. p. 242. Ferguson's *Lectures, Appendix*, vol. ii. p. 210, which contains a full view of what has been done by preceding authors. Dr. Thomas Young's *Nat. Phil.* vol. i. p. 176; vol. ii. additions, p. x. Donkin, *Nicholson's Journal*, vol. vi. p. 86. Robertson Buchanan *on the Teeth of Wheels*, Lond. 1808. Hachette's *Traité Elementaire des Machines*, p. 282. Ferny, *Essai sur l'Art de construire les Machines*, Par. 1812. Borgni's *Essai sur la Composition des Machines*. Paris 1819.

CHAP. III.

ON THE MECHANICAL CONTRIVANCES FOR CONVEYING THE POWER FROM THE IMPELLED TO THE WORKING POINT OF MACHINES.

In all machines beyond the limits of the simple mechanical powers, the power of the first mover must be conveyed to the place where the work is to be performed, by means of mechanical contrivances, which vary according to the nature of the impelling power and the work to be performed, and of the respective localities of the first mover, and the working part of the machine. The skill of the engineer is in no way more conspicuous than in the intermediate machinery by which he transmits and modifies the action of the prime mover; and the general machine must derive its character of utility and durability from the simplicity of the intermediate machinery, and the judgment with which the individual contrivances are selected.

In order to convey some general idea of the composition of machines, we shall lay before our readers a description of some of the leading mechanical contrivances which are in constant use in machinery, and explain the methods by which the direction of motion may be anyhow changed, and by which one kind of motion may be converted into another.

SECT. I. *On the Mechanical contrivances used in the composition of Machines.*

These contrivances may be classed in the following manner:—

- I. Contrivances in which the acting parts have no permanent connexion.
    - 1. Cylindrical wheels and pinions.
    - 2. Bevelled or conical wheels.
    - 3. Rackwork.
    - 4. Belts, bands and ropes.
    - 5. Pins, hooks and chains.
    - 6. The lever of Lagaroust.
- II. Contrivances in which the communicating parts have a permanent connexion.
    - 1. Crank, single and double.
    - 2. Hooke's universal joint, single and double.
    - 3. Sun and planet wheel.
    - 4. Ball and socket.

I. *On Contrivances in which the acting parts have no permanent connexion.*

1, 2, 3. In the preceding chapter, we have explained, at full length, the method in which cylindrical and bevelled wheels and rackwork convey motion from one part of a machine to another; and we need not therefore resume the subject at present.

4. *Belts, bands, and ropes.*—When it is required to convey the force of one wheel to another, the simplest of all methods is to connect them by means of leather belts passing over the circumference of each. This contrivance is shown in Plate LXI. Fig. 2, where the belt X passes over the wheel E; but still better in Plate CVII. Fig. 1, where the wheel D is put in motion by the belt passing round the large wheel A. When the large wheel A is put in motion, the belt is also turned round by its friction upon the circumference, and by the same cause it puts in motion the wheel D. The great advantage of belts is, that by means of them we may convey the motion of one wheel to another at a very great distance, which could not be done without considerable expence by wheels and pinions; but they have the disadvantage of stretching so as to become loose, and thus lose their power of turning the wheel. This evil, however, may be instantly remedied by shortening them, or by increasing the friction by means of chalk. Sometimes this evil is remedied by having grooves of different diameters in one or both of the wheels; and when the belt or rope becomes slack, it is shifted to the following groove; but this can be permitted only in machines, such as turning lathes, where a change of velocity is of no importance. When the second wheel D is to move in the same direction as the first wheel A, the band must simply pass over their circumferences, as in the figures referred to; but when the wheel is required to move in a contrary direction, the belts must cross one another at a point between the two wheels. This crossing, however, cannot be easily effected with belts, unless they are very long; and in this case *ropes* are always employed, as shown at *b*, Plate VIII. Fig. 122. and in Plate IX. Fig. 1. where the wheel V is driven by a crossed rope. When ropes are used, they always move in grooves cut in the circumference of the sheaves or wooden wheels round which they pass.

5. *Chains and hooks.*—When there is a great strain upon the machinery, and when its motions are required to be regular, belts and ropes cannot safely be employed. Chains are therefore substituted in their place with peculiar advantage. Sometimes these chains are like those of a watch, as shown in Plate CCCVI. Fig. 1. and 3, or at W x, in Plate CCCXXIII. Fig. 10, in which case they act like the belts and ropes, by simple friction on the surfaces round which they pass; but in general it is necessary to give other forms to the chains, and to make them act by laying hold of pins or hooks projecting from the circumferences round which they pass. Three of these chains are shown in Plate CCCLXV. Fig. 14, 15, and 16. In Fig. 14, the links of the chain ABC take hold of the pins p, p, projecting from the circumference of the wheel DE. In Fig. 15, the chain has a simpler structure. In Fig. 16, there are projecting teeth t, t, upon the jointed chain ABC, which enter into grooves or indentations on the circumference of the wheel. Various chains, for the purpose of machinery, are shown in Fig. 17. The one marked A, was invented by Vaucanson

6. *The Lever of Lagaroust.*—This contrivance, which has the property of producing a continued rectilineal motion from an alternating circular motion, is shown in Plate CCCLXV. Fig. 18. The lever AB moves round an axis C attached to a fixed beam MN. A toothed rack or beam FG is capable of descending and ascending freely by the action of the hooks or teeth at the end of the two secondary levers DE, D′E′ fixed at the points D, D′ of the great lever AB. When the end A descends, the hook E′ falls down upon the teeth below it, while the simultaneous ascent of the end BC causes the hook E to draw upwards the beam FG. By now depressing BC, the hook E falls down upon the teeth below it, while the ascent of AC causes the hook E′ to draw upwards the beam FG. The very same contrivance may be employed to give a circular motion to a wheel having its circumference furnished with teeth like those upon FG.

II. *On Contrivances in which the communicating parts have a permanent connexion*

1. *The Crank.*—The crank is one of the simplest and most durable of all contrivances for conveying motion. It is in principle the same as a wheel with the power applied at or near its circumference, as shown in Plate CCCLXV. Fig. 19. where the wheel A is fixed at the end of an axle which does not project in front. If the axis, however, projects or extends on both sides of the wheel, it must receive the form shewn at *a*, in Plate CVII. Fig. 1, where it is employed to communicate to the wheel A a rotatory motion, by the reciprocating rectilineal ascent and descent of the handle or footboard B. A double crank is shown in Plate CCCLXV. Fig. 20. where $m\,n$ is the revolving axis, which, by means of the double crank, communicates a reciprocating motion to the two beams $a\,b$, $c\,d$, the one ascending when the other is descending. A triple crank is shown in Fig. 21, where three beams are made to ascend and descend; but the planes passing through each of the three cranks must be inclined 120° to one another. A changeable crank, in which the radius is variable, is shown in Fig. 22, where $m\,n$ is the axis, and $a\,b$ the beam, which can be set to different distances from $m\,n$, by drawing up the four parallel bars, c, d, e, f, and fixing them in any position, by pins passing through the small holes. See Art. 3.

2. *Hooke's universal joint.*—This ingenious contrivance, which is shown in Fig. 23, consists of two shafts, or axes A, B, terminating in a semicircle, and connected by means of a cross CD, EF. As the branches CD, EF have a motion round their pivots at C, D, E, and F, it is obvious that when the shaft A is turned round, a similar motion will also be communicated to the shaft B. This joint may be used when the inclination of the shaft does not exceed 40°, or rather 140°, its complement. When the inclination of the shafts is between 50° and 90°, a *double universal joint* is employed, as shown in Fig. 24. Here there are two crosses, the extremities of which move on their pivots in the semicircles at the ends of the rafts. These joints may also be constructed with four pins, fastened at right angles upon the circumference of a hoop or a solid ball. The single universal joint is shown in use in Plate XLV. and at M, in Plate XLVIII. Fig. 5.

3. *Sun and planet wheel.*—This contrivance was first introduced by Mr. Watt, for the purpose of converting the reciprocating motion of the beams of

his steam engine into a rotatory one. The wheel M, (Plate CCCLXV. Fig. 25.) called the planet wheel, is fixed at the end of the beam *a b*, and this wheel is bound to the sun wheel N by a strap of iron *a c*, so that the two wheels are permanently fixed together. As the beam *a b* rises and falls, the moveable wheel M acts upon the fixed wheel N, revolves round as it were upon its circumference, and communicates to it a continuous rotatory motion.

Mr. Watt was the first person who applied the crank to steam engines; but as, in the rotatory motion produced by the crank in its common form, the impulse is given only in one direction, it must be continued in the opposite direction by the momentum of the wheel, which acts as a fly. As Mr. Watt was unwilling to load his engine with a fly heavy enough to continue the motion during the ascent of the piston, he proposed to employ two engines acting upon two cranks fixed on the same axis, at an angle of 120° to one another, with a weight on the circumference of the fly, at the same angle with each of the cranks. This method, which required only a very light fly, and by means of which the motion might be rendered nearly equable, had occurred to Mr. Watt very early; but the workman whom he employed to make the model of it, communicated the secret to another person, who took out a patent for the application of the crank to steam engines. This event led Mr. Watt to try to accomplish the same object by other means; and accordingly, in the year 1781, he took out a patent for several methods of producing rotatory motions from reciprocating ones; one of which was the contrivance of the sun and planet wheel. "This contrivance," says Mr. Watt, "was applied to many engines, and possesses the great advantage of giving a double velocity to the fly, but is perhaps more subject to wear, and to be broken under great strains, than the crank which is now more commonly used, although it requires a fly-wheel of four times the weight, if fixed upon the first axis. See Robison's *System of Mechanical Philosophy*, vol. ii. p. 134, note.

4. *Ball and Socket.*—Although the ball and socket is not used in general machinery, yet we may regard it as a mechanical contrivance, by which two parts of a machine are permanently connected. The object of it is to give a motion in various directions to one axis while the other remains fixed. This is generally done in telescopes, by the joint effect of a horizontal and a vertical movement; but when the telescope is not heavy, a ball and socket is the simplest and most commodious contrivance. It is represented in Plate CCCLXV. Fig. 26. where B is a *ball* of brass, fixed at the lower extremity of the axis AB, on which a telescope or any other body is supported. This ball is of the same diameter as the interior diameter of the *socket* or cap CSD, with which the lower axis ST is terminated. This socket consists of two parts CEFD, EFS, the former of which can be removed, or slackened, or tightened by turning the milled circumference EF. On the bottom of the socket is placed a piece of cork, against which the lower part of the ball B presses, so that whenever the ball moves too loosely in the socket, it may be pressed against the elastic cork, by turning EF, which draws the ball downwards, by which means its motion is rendered as stiff as we choose. In the upper edge of the moveable part CD, a groove *n* is cut to allow the axis AB to come into a position at right angles to ST.

SECT. II. *Account of Mechanical Contrivances for transferring motion, or changing its direction.*

In the preceding section, we have mentioned only those means which are used in connecting together the different parts of machinery, without any reference to the nature of the effect which they individually produce. We shall now proceed to consider the various contrivances which have been adopted for changing the direction of motion.

I. *Contrivances for transferring a direct circular motion into a direct circular motion in the same plane.*

The simplest way of producing a direct circular motion from a motion of the same kind, is by means of a belt, rope, or chain, which does not cross between the two wheels. In Plate CVII. Fig. 1. where this is represented, the wheel D obviously moves in the same direction as A.

The same effect may be obtained by means of *three* wheels acting upon one another, as in Plate CCCLXIV Fig. 1. where, if the right hand wheel is turned from left to right, it will cause the middle wheel to turn from right to left, and the left-hand wheel from left to right. The same effect is likewise produced by one wheel acting upon the interior circumference of another.

II. *Contrivances for changing a direct circular into an inverse circular motion in the same plane.*

This effect may be produced by a crossed belt, rope, or chain, as shown in Plates VIII. and IX. or by one toothed wheel acting upon another.

III. *Contrivances for changing a circular motion in one plane into a circular motion in any other plane.*

A motion in any one plane may be changed into a motion in any other plane, by means of bevelled or conical wheels, as described in p. 652, and the same effect may be produced by Hooke's universal joint. Examples of this may be seen in Plate CCLXXXI. Fig. 7. and in Plates CCCXXI. Fig. 5. 6. CCCXXII. Fig. 2. where the motion is changed into a plane variously inclined to the original one. The same effect may be produced by an endless screw working in the teeth of a wheel. In Plate CCCLXII. Fig 17. the motion is represented as changed into a plane at right angles to that of the handle; the wheel, however, may have any degree of inclination to the horizon; but the common section of its plane, and that of a plane passing through the axis of the screw, must always be parallel to the axis of the screw.

A similar effect may be produced by the contrivance shewn in Plate CCCLXV. Fig. 27. which is used in Piedmont for silks. It consists of a small wheel AB, having several portions of the thread of a screw upon its circumference. These portions act upon the teeth of the vertical wheel CD; and when one portion of the screw has raised up one tooth to its highest point, the following tooth is seized by the next portion of the screw. See Lanz and Betancourt, *Essai sur la Composition des Machines*, p. 99.

IV. *Contrivances for transferring and changing a circular motion into another of the same kind.*

A contrivance of this kind, invented by M. Camus, for the purpose of moving sieves, is shewn in

Plate CCCLXV. Fig. 28. where ABCD is a table above which is a plank EF, capable of revolving round the pivots *m n*. To this plank, or to one of the pivots *m* prolonged, is fixed a crooked arm *s*, upon which is suspended a pendulum RS. By means of the moving power, the pendulum is put into a circular alternating motion, and, of course, the same motion is communicated to the plank EF.

Another contrivance for this purpose is shewn in Fig. 29. where *a b c* is a cord fixed at *a* to the spring B, and after passing round the cylindrical wheel A, it is fixed at *c* to the pedal D. The circular alternating motoin of the pedal D round the centre C is thus communicated to the wheel A.

A third contrivance, for the same purpose, is shewn in Fig. 30, where a circular alternating motion is communicated to the wheel M by means of the circular alternating motion of the pedal D, communicable by the rope passing over the pulley A.

SECT. III. *Account of Contrivances for changing one motion into another of a different kind.*

In the preceding section, we have considered only the methods of changing one motion into another of the same kind, either into a new plane or into a different place. We shall therefore proceed to consider the different kinds of mechanism by which motions are changed into others of a different kind. These changes may be thus arranged.

1. A rectilineal continuous motion into a circular continuous motion.
2. A rectilineal continuous motion into a circular alternating.
3. A rectilineal continuous motion into a rectilineal alternating.
4. A circular continuous motion into a rectilineal alternating.
5. A circular continuous motion into a circular alternating.
6. A rectilineal alternating into a circular alternating.

I. *Contrivances for converting a rectilineal continuous motion into a circular continuous motion.*

This effect may be produced by the following means:

1. By the descent of a weight attached to a cord wrapped round the circumference of a cylindrical wheel or axle. The weight, by its continuous rectilineal descent, gives a circular continuous motion to the wheel or axle. See Plate CCC. Fig. 1. where the weight A gives this motion to the axle *a a*, by the rope acting on the circumference B.

2. By a rack acting upon teeth in the circumference of a wheel, as shown in Plate CXXXVII. Fig. 1. where the continued rectilineal motion of the rack gives a continuous circular motion to the wheel.

3. By a rectilineal belt, rope, or chain, acting in the direction of a tangent to the circumference of a wheel.

4. By a nut, with a female screw advancing along a male screw.

II. *Contrivances for converting a rectilineal continuous motion into a circular alternating motion.*

This effect may be produced by the following means:

1. By the teeth of a rack MN. (Plate CCCLXVI. Fig. 1.) acting upon the extremity B of a lever AB moving round the centre C. After the head A has been raised by any tooth acting upon B, it again descends by its own weight through the same arch; and as soon as its descent is completed, it is again caught by another tooth, which raises it as before. The same effect may be produced by a chain with teeth, which act upon notches cut in the circumference of a wheel fixed at B. This elementary machine has escaped the notice of Hachette, Lanz and Betancourt, and M. Borgnis.

2. The same effect may be produced by a double rectilineal rack acting upon a double wheel, as shewn in Fig. 2. where ABCD is the double rack, having sets of teeth on each side, with intervals without teeth, the sets of teeth on the side CD being opposite the intervals on the side AB. Between the arms of this double rack is fixed a double wheel *a b*, *c d*, the half *a b* has a smaller diameter than the other, and is furnished with a few teeth, which are acted upon by the teeth of the rack CD, and the other half *c d*, is also furnished with teeth, which are acted upon by the teeth of the rack AB. When the rack ABDC descends, the first tooth upon CD acting upon the first tooth upon *a b*, gives the double wheel a rotatory motion from left to right, and the remaining teeth of the first set conduct it through a given arch. When this arch is completed, which happens when the last tooth of the first set upon CD acts upon the last tooth upon *a b*, the first tooth of the first set upon AB begins to act upon the first tooth upon *c d*, and therefore causes the double wheel to move backwards through the same arch. In this way the circular alternating motion of the double wheel will continue as long as the rack continues to act upon it. This elementary machine has also escaped the notice of Hachette, Lanz and Betancourt, and M. Borgnis.

3. The *Lever of Lagaroust*, which we have already described, and represented in Plate CCCLXV. Fig. 18, is also a contrivance by which the rectilineal continuous descent of the arms, D, D′ produces an alternating circular motion round the centre C.

III. *Contrivances for converting a rectilineal continuous motion into a rectilineal alternating motion.*

1. The only contrivance which we think capable of producing this effect is shewn in Fig. 3. of Plate CCCLXVI. A beam AB moving in the direction AB, and furnished with wipers *m*, *n*, *o*, will obviously raise the arm CD through a certain height. As soon as the wiper quits it, it will descend by its own gravity, and will then be elevated by the subsequent wiper *m*, having an alternating rectilineal motion of ascent and descent. This elementary machine has escaped the notice of Hachette, Lanz and Betancourt, and M. Borgnis.

IV. *Contrivances for converting a circular continuous motion into a rectilineal alternating motion.*

The contrivances which have been invented for producing this change of motion are very numerous, and some of them highly ingenious. Innumerable pieces of mechanism might be devised for this purpose; but it is our object at present to exclude all those in which the effect is produced by more than two or three parts; as all contrivances of a more complicated nature must be considered as real machines, and not as elementary ones.

1. The simplest methods of producing a rectilineal alternating motion from a circular continuous one, are those which consist in raising a beam or stamper vertically, by wheels formed into an irregular outline, or car-

rying on their circumferences, wipers or spirals, as shewn in Plate CCCLXV. Fig. 3. The stamper is thus raised to a certain height, and descends through the same height by its own weight, when the succeeding wiper begins to act upon it, and raise it a second time. The very same effect may be produced by a rack and pinion, provided the pinion has teeth only on a part of its circumference. The toothed part elevates the rack, which of course descends when the last tooth has ceased to act, and by the time that the rack has performed its work, the toothed part of the pinion has come round again, for the purpose of raising the rack a second time. All these contrivances are so simple and well understood, that they do not require to be more particularly described.

2. Another contrivance for producing this effect, is shewn in Plate CCCLXVI. Fig. 4, where A is a wheel turned by the winch H, and connected by the bar $a\ b$ with the vertical beam MN, which can move up and down between the guides $c\ d$, $e\ f$. As the handle H is turned, the beam MN will move up and down, its greatest range being equal to 2 A b. If the beam MN is placed horizontally, the same effect will be produced. When the power of a man is to be applied to the handle H, the wheel A is unnecessary; and we have only to join the extremity b to the centre of motion A, and convert it into a crank. But when the motion is to be taken from any other shaft in motion, it is generally done by a belt or chain going round the wheel A. This apparatus may be employed for grinding and polishing flat surfaces, and is used in silk mills. See Bailey's *Machines*.

3. In Plate CCCLXVI. Figs. 5 and 6, we have represented other two contrivances, which are essentially the same. In Fig. 5. a pinion P, having teeth on nearly one half of its circumference, is placed within a double rack ABCD. After the pinion turning from right to left has raised the double rack by acting upon DB, it then proceeds by continuing to turn in the same direction to act upon the side AC, and depress the double rack. If the teeth of the wheel were infinitely small, the half of the wheel ought to be furnished with teeth, and the length of the rack should be exactly equal to the toothed part. See *Machines Approuvées*, tom. iv. No. 223; *Repertory of Arts*, vol. xii. p. 141; Berthelot's *Mecanique Appliquée aux Arts*, &c. i. p. 79, ii. p. 36 and 40; Leupold's *Theatrum Machinarum*, chap. 12; and Ramelli *Theatre des Machines Hydrauliques*, 1724, tom. ii, pl. 40.

The contrivance shewn in Fig. 6, consists in reducing the teeth of the rack to one, and in diminishing the number of teeth in the wheel. When the wiper a turning from left to right has raised the rack by acting upon m, the wiper b begins to depress the rack by acting upon n; and in this way the alternate motion is continued.

4. The rack and pinion of the form shewn in Plate CCCLXVI. Fig. 7, produces a similar effect. When the teeth of the pinion P have acted upon one side of the rack, and begin to enter upon the circular end, a small lateral motion is given to the rack by means of the jointed pieces $a\ b$, $c\ d$, which brings the other side of the rack within the action of the pinion, and enables it to work on the opposite side to produce the returning motion.

5. The contrivance shewn in Plate CCCLXVI. Fig. 8, consists of a plate of metal A B, with a number of rectilineal openings, $a\ b$, $c\ d$ cut through and through it. Behind this plate, and very near it, is another MN, in which a spiral aperture marked with a dotted line is also cut through and through. If small cylinders r, s are placed in the opening at the intersection of the spiral and the rectilineal apertures, it is obvious that these cylinders will approach to, or recede from, the axis, by turning the plate MN, as they must always be found at the points of intersection. If two contrivances of this kind are placed together, as shewn in the section, Fig. 8. and if the small cylinders r, s, in each set of plates, are connected with one another by means of straight rods $n\ n$, $n\ n$, these rods will form the circumference of a drum of a greater or less diameter, according as the cylinders r, s recede from, or approach to, the centre. By this means an *expanding crane* is formed, by which the relation between the power and weight can be varied at pleasure. This is the principle of the expanding crane invented by Mr. Robert Hall, and described in the *Transactions of the Society of Arts*, vol. xii. and in the *Phil. Mag.* April, 1804. See also the *Repertory of Arts*, vol. xvii. p. 11. An expanding pulley upon a different principle is described in Part II. Chap. III.

6. Another contrivance is shewn in Plate CCCLXVI. Fig. 9. where AB is a wheel turned by a winch or by a belt upon its circumference. Its exterior part is cut into teeth, the form of which may be varied according to the nature of the case. A small rod $a\ b$, supported between two guides m, n, has one of its ends a bearing upon the teeth of the wheel, while its other extremity b buts against a spring s. As the wheel AB turns round, an alternating rectilineal motion is obviously communicated to the rod $a\ b$. M. Zureda, an eminent Spanish engineer, has applied this contrivance to a machine for pricking holes in leather for making cards, and it has also been employed in the manufacture of fishing nets. See Leupold's *Theatrum Machinarum*, tom. ii. pl. 36, fig. 3. If all the teeth in AB were reduced to one, the surface of the wheel would be an inclined plane, and the oscillations of $a\ b$ would be performed in every revolution of the wheel.

7. A very ingenious mechanism, invented by M. Zureda, is shown in Plate CCCLXVI. Fig. 10. where AB is a cylinder turning round its axis, either by the handle H, or by a belt going round a wheel at one end of it. On its surface are cut two opposite grooves like the threads of a screw, which unite or run into one another at both ends of the cylinder. The lower extremity b of the small rod $a\ b$ exactly fills this groove, and its upper end a has a head attached to it, which runs in a groove made in the frame CD. By turning the handle H the rod $a\ b$ follows the spiral direction of the grooves till it reaches the end B; and as this end of the groove communicates with the commencement of the opposite groove, the rod $a\ b$ returns to its original position by the opposite groove. See Lanz and Betancourt's *Essai*, &c. p. 62. Edit. 1819. If the cylinder in this mechanism is converted into a cone, the path of the small rod $a\ b$ may have any inclination to the axis of the circular motion.

8. Two analogous contrivances are shewn in Plate CCCLXVI. Fig. 11. and 12. A wheel AB, Fig. 11. turned by a handle H, or by a belt, has a projecting pin or cylinder C, which is made to move with a little play in the rectilineal groove DE, cut in a cross piece DE, attached to the ascending and descending rod $a\ b$, supported vertically by the guide $m\ n$. As the wheel turns, the cylinder C, acting upon the lower side of the groove, depresses $a\ b$, and bringing it to its lowest point, it raises it by acting upon the upper side of the groove, and

thus gives the beam ab a rectilineal alternating motion. As the quantity of descent or ascent is always equal to the versed sine of the arch described by the wheel, the motion of the beam ab is very slow at the beginning and end of each oscillation, and varies rapidly towards the middle.

This want of uniformity is remedied in the contrivance shewn in Fig. 12. where the groove DE, instead of being rectilineal, is formed into two similar curves, as shewn in the Figure. In order that the beam ab may descend through equal spaces p 1; 1, 2; 2, 3, &c. while the pivot s describes the equal arcs s 1; 1, 2 of the arch p D, it is obvious that the point p of the beam must be at the points, 1, 2, 3, of the radius of the wheel, while the pivot s is at the divisions 1, 2, 3, &c. of the quadrant of the circle. Hence the distances 1, 1, 2, 2, between the quadrant and the curvilineal groove, must be taken equal to s 1, s 2, s 3 of the radius. The other quadrants of the curve are formed in the same manner. But it must be noticed, that if the pivot s causes the beam ab to move through a space exactly equal to what it moved through when it described the first quadrant, then the curves must cross one another at s like the figure ∞. If it is required that the beam ab moves through a smaller space in the 2d than in the 1st quadrant, then the form of the curves must be that in the figure where the two branches are separated at s; but if it is required that the beam should describe a greater space, then the curves will cross one another at two points, thus ∼∼. All this is so obvious, that it scarcely requires any farther illustration.

9. Another contrivance is shewn in Plate CCCLXVI. Fig. 13. where AB is a double rack with circular ends driven by a pinion P, which can move freely in a groove mn cut in the cross piece CD; then if, when the pinion P comes to the end B, the projecting piece a meets the spring s, the pinion P will descend in its groove, and carry back the other side of the rack, so that the alternate rectilineal motion of the rack will thus be kept up continually.

10. Another contrivance is shewn in Fig. 14. where AB is a concave toothed wheel, in which another wheel C of half its diameter works. If this wheel C is driven by a handle, so as to make it revolve within the other, any point of its circumference will describe a straight line. This is obvious from our article Epicycloid, where it is shewn, that the interior epicycloid thus described is a straight line.

In all the preceding contrivances, the rectilineal alternating motion is performed in a path which has absolutely the same position in every successive oscillation. It may, however, often be necessary that this path should be different in different oscillations. If, for example, we wish to bruise any thing with a stamper, it may be required that the stamper should not always fall upon the same spot, but should strike different places at different times. The following contrivance for producing this compound rectilineal alternating motion has been proposed by Dr. Brewster.

11. Let it be required to raise a stamper vertically, so that it shall strike different places, at the end of different oscillations. If the rectangles A, B, C, D, (Plate CCCLXVI. Fig. 15.) represent the curvilineal acting surfaces of four wipers lying in different planes, let grooves ab, $a'b'$ be cut into two of them, so as to conduct laterally the pin, or projecting point, by which the stamper is raised, and let the other two have similar grooves cd, $c'd'$ cut in an opposite direction. Then, when the pin of the stamper is taken up at the point a of the groove upon A, it will be conducted in the groove ab, and quitted at b, so as to have received a lateral displacement equal to aa'. It will then be taken up by the point a' of the groove $a'b'$ of the wiper B, and in like manner conducted to b', where it falls. The next wiper C will take it up at the point c of its groove, and conduct it back again to d, where it quits it; and here it is taken up by the fourth wiper D at c', and conducted by the groove $c'd'$ to the point where it was when it was taken up by the wiper A. The only practical difficulty in this construction consists in guiding the stamper during its lateral displacement.

V. *Contrivances for converting a continuous circular motion into an alternating circular motion.*

1. This effect may be produced by means of wipers fixed upon a wheel, and raising a forge hammer A B moveable round a centre, as in Fig. 1. Plate CCCLXVI. where the teeth or wipers are fixed upon a straight line instead of a wheel. An application of this mechanism is also shewn in a machine used in bleaching, represented in Plate LV. Fig. 6. This contrivance admits of numerous varieties, but they are all precisely the same in principle.

2. Another contrivance, shewn in Plate CCCLXVI. Fig. 16. consists of a wheel AB with one tooth as it were, or an inclined plane MN fixed upon its outer rim. This plane acts against the extremity a of a crooked lever abc, and gives it an alternating vibrating motion round the centre C, the extremity a being always pressed against the plane in its returning oscillation by the spring s. If the bent arm Cba of the lever is heavier than the other arm, the spring will be unnecessary, as the lever will return like a pendulum by its own gravity. The plane of the wheel may have any position with regard to the horizon.

3. Another piece of mechanism for this purpose is shewn in Plate CCCLXVI. Fig. 17. where A is a wheel partly toothed; and B, C other two toothed wheels upon the same axis DE. After the toothed arch of A has driven the wheel B through a certain arch, it then quits it, and begins to act upon C in an opposite direction, by which means an alternate circular motion is communicated to the axis DE.

4. A contrivance invented by M. St. Cyr, for changing an uniform circular motion into an alternating circular motion, the velocity varying according to a given law, is shewn in Plate CCCLXVI. Fig. 18. The use of it is to construct equation clocks. The annual wheel A carries the equation curve BCD, in the rim of which is cut a groove, in which the pivot E is guided. This pivot is connected with the levers EF and EG, the latter of which is attached to the cannon H, which carries the minute hand HI, so that it follows the vibration of the curve in more than one half of the circumferences of the minute dial, and which is sufficient for marking the inequalities arising from the equation. See *Machines Approuvées*, tom. iii. No. 146. tom. iv. No. 235, 269, 278, tom. vii. No. 488, 495; for other contrivances of this kind, see Horology.

5. The crank, which we have already described in p. 660, is another contrivance for converting an alternating circular motion into a continuous circular motion,

6. The sun and planet wheel, invented by Mr. Watt, and represented in Plate CCCLXV. Fig. 25. is also a contrivance for the same purpose. See p. 660.

7. The lever of Lagaroust, where the ratchet wheel is circular, likewise answers the same purpose. See pages 660 and 662, and Fig. 18. Plate CCCLXV.] This contrivance admits of the modification shown in Fig. 19, Plate CCCLXVI. where the lever AB turns round the point C, above and below which are two rods E, D, moveable round pins on AB, and so formed at their other extremities as to rest upon the spindles or teeth of the wheel MN. When the end B is pushed towards the wheel, the ends of the rods E, D push against the spindles, and drive the wheel round; and when B moves backwards from the wheel, the rods D and E fall from the spindles which they formerly acted on, upon the subsequent spindles, which they push forward at the next returning vibration of BC.

8. The various *escapements* which we have described in our article Horology, may also be ranked in this class of elementary machines.

9. A very ingenious contrivance for converting a circular continuous into a circular alternating motion, has been used by Messrs. Dollond in giving an angular motion to the reflecting mirrors of the Kaleidoscope. It is represented in Fig. 20. Plate CCCLXVI. where AO, BO, are the two reflectors moving rounds the points x x, as centres. They are attached to plates of brass cd, cd, whose breadth exceeds that of the reflectors, so as to allow their extremities to descend below the point O. A double spring y x, x y, presses upon the back of the reflectors, and keeps them in contact, as shown in Fig. 20. and is sufficiently elastic to allow them to open, as in Fig. 21. The milled head MN carries at its other end a very eccentric button or wheel, the least diameter of which is seen at m, Fig. 20. and the greatest at m, Fig. 21. In the first position, it has allowed the reflectors to come into contact at O, and in the other it has forced them open into the position of parallelism. By turning the milled head, and consequently the eccentric button attached to it, the lower ends of the reflectors may be brought to any distance less than OO. See Dr. Brewster's *Treatise on the Kaleidoscope*.

VI. *Contrivances for converting a Rectilineal alternating into a Circular alternating motion.*

The pieces of mechanism which have been invented for this purpose, are of very great use in the arts, and deserve to be carefully studied by those who are professionally occupied with the construction of machinery.

1. A very simple contrivance of this kind is shown in Fig. 22. Plate CCCLXVI. where AB is a lever moving round C. The two extremities of a rope, fastened at the points D, F, pass round the semicircle DEF, and after crossing below E, pass over two sheaves M, N. If we turn the lever round C, by depressing B, the Point L of the rope will obviously move towards N, and if we raise the extremity B, the same point L will return to its former place. Hence this point receives a rectilineal alternating motion from the circular alternating motion of the lever.

2. The contrivance represented in Plate CCCLXVI. Fig. 23. and known by the name of zig-zag, or lazy scissars, produces a similar effect. All the pieces of which it is composed are jointed, or have a common pivot at the place of their intersection. When the ends M, N are made to open or shut round the pivot B, the points A and B approach to or recede from one another in a regular time. See *Machines Approuvées*, tom. vi. No. 429. Besson's *Theatre des Instruments de Mathematique*, Lyon 1579; and Borgnis' *Essai, &c.* p. 163, 164.

3. A third contrivance for the same purpose is represented in Plate CCCLXVI. Fig. 24. which is nothing more than the common bow used by watchmakers for drilling holes. The cord AB, passing round the sheaves C, gives the latter a circular alternating motion when the bow is drawn backwards and forwards.

4. A lever, with two arched heads or ends working in a vertical rack, or raising a weight by means of a chain passing over the arched ends, the weight descending by its own weight, is also a machine which produces the same effect.

5. In Plate CCCLXVI. Fig. 25. the wheel AB approaches to the point C, by turning it round its axis in one direction, and recedes from it by turning it round in the opposite direction. The ropes AC, BC, being twisted round the axis CD, necessarily shortens the distance between AB and C, while their untwisting increases that distance. This contrivance is often used for drilling or boring with the extremity D.

6. Another contrivance for this purpose is shown in Plate CCCLXVI. Fig. 26. where the rod a b rises and descends vertically, between the two guides m n, m n, by means of the alternate circular motion of the lever AB moving round the centre C, and connected with a b by the rule BD, having an axis of motion at each end.

7. The ingenious contrivance invented by Mr. Watt, for giving a rectilineal motion to the piston of the cylinders of his steam-engines, by means of the circuluar alternating motion of the beams, belongs to this class of machines, and will be found described in our article on the steam-engine. It is called *the parallel motion*, and admits of many varieties. The history of this beautiful machine, which has been erroneously given by M. Prony, (as Mr. Watt himself has often informed us) will be found in Dr. Robison's *System of Mechanical Philosophy*, vol. ii. p. 152. Mr. Watt did not borrow the idea of the parallel motion, as Prony asserts, from Suardi's pen; and it is remarkable, that the very *first* and *rudest* form in which Mr. Watt used the parallel motion, is the same as that which was brought forward by M. Betancourt as a new invention, and described in Prony's *Architecture Hydraulique*, Part ii. p. 67. and 123. See our article Steam Engine, where the fullest details respecting this ingenious contrivance will be given.

8. In Fig. 27. Plate CCCLXVI. we have represented a very ingenious contrivance employed in Dr. Brewster's Universal Kaleidoscope, as constructed by Mr. Ruthven, and by which an alternating circular motion is given to the reflecting mirrors by a rectilineal alternating motion. It consists of a frame of brass ABEFGH, the two sides of which AB, FH, are kept together by four cross pieces ab, cd, &c. the other two corresponding to these being invisible in the figure. The two reflectors, the ends of which are seen at A'O, B'O, are each fixed to a plate of metal p p, a section of which is seen in Fig. 28. Each plate of metal has four cylindrical pins p, p, &c. both on its upper and under edge. The two pins nearest the ends of the reflectors pass through openings in the cross pieces a b, c d. On the top of the frame is placed a plate of brass MNQP, in which are cut grooves e f, g h, k l, m n, e f and k l being parallel to each other, and also g h and m n. This plate can be pushed forwards and backwards

between the cross pieces *a b*, *c d*, by means of a button S, fixed upon the plate, and as the middle pins *p p*, attached to the plates which carry the reflectors, pass through these grooves, any change in the position of the plate MQ produces a change in the distance *p p* of the pins, and consequently in the distance of the upper edges of the reflectors. By pushing the button S, therefore, to the left, the upper edges of the reflectors may be brought into contact: and by pushing it to the right, they may be separated to any distance, depending on the length and inclination of the grooves *e f*, *g h*. A similar plate with a similar button is placed upon the lower edges of the reflectors, so that we are furnished with the means of giving the plates any inclination to each other, or placing them at any distance within certain limits. If the lower edges of the plates are brought into contact, by pushing the lower button to the left, we can vary the angle of their inclination, or give them a circular motion round their common section, by pushing the upper button either to the right or to the left. See Dr. Brewster's *Treatise on the Kaleidoscope.*

CHAP. IV.

ON THE REGULATION OF MACHINERY BY MEANS OF FLY WHEELS AND OTHER CONTRIVANCES.

Amid the great variety of machines which have been applied to the practical purposes of life, there is scarcely one in which there is not a deviation from a uniformity of action, arising either from the nature of the impelling power, from the nature of the machinery to which it is applied, or from the nature of the work to be performed.

1. When horses or men are the first movers of machinery, the mechanical force which they exert is liable to great variation. When fresh and vigorous, they act with considerable force and steadiness; but after pulling for some time, the commencement of fatigue impairs their activity; and when they have to strive against a great resistance, they indulge in frequent and short relaxations, and then recommence their labour with renewed vigour. A constant variation in the velocity of the machine is the necessary consequence of this unequal action, and by this means the communicating parts of the machinery are not only injured, but the work itself is often ill performed, and the animal is subject to additional fatigue in dragging the whole machinery from a state of rest.

2. When the first mover is inanimate, an inequality of force evidently arises from a variation in the velocity of the wind, from an increase or diminution of water, arising from sudden rains and great droughts; or from an increase or decrease of steam in the boiler, arising from a variation in the heat of the furnace. In the spiral spring, too, its force is a maximum when it begins to uncoil itself, and it gradually diminishes till its force is entirely exhausted.

3. A desultory motion in machines arises also from the nature of the machinery by which the power is applied. In the single-stroke steam engine the impelling power is so unequal, that for two or three seconds it does not act at all; and even in the double-stroke steam engine, the beam and all its appendages are brought completely to rest, and must be again dragged into motion at the returning stroke. In applying his power by means of a crank, a man exerts the greatest force when he pulls the handle upwards from the height of his knee; and his force is a minimum, when the handle being in a vertical position is thrust from him in a horizontal direction. Hence Desaguliers found, as we have already stated in p. 643, col. ii. that when this irregularity was corrected by placing two handles at right angles to one another, and making two men drive them, their individual action was 35, whereas with one handle it was only 30.

4. A variation of velocity may frequently arise from the nature of the work to be performed. In thrashing-mills on a small scale, when too much of the corn is taken in by the fluted rollers, the increase of resistance immediately retards the machinery, and communicates a desultory motion even to the water-wheel itself. In the pile engine invented by M. Vauloue, a similar variation arises from the nature of the work, which is to raise a great weight in order to drive piles. The machine is drawn by horses, and as soon as the ram or weight is elevated and discharged, the resistance against which the horses have been struggling is suddenly removed, and they would instantly fall to the ground, were not this sudden diminution in the resistance counteracted by a mechanical contrivance.

Having thus pointed out the causes of a variation in the velocities of machines, we shall now consider the contrivances by which their motion may be regulated or rendered uniform.

SECT. I. *On Fly Wheels.*

The simplest of all contrivances for regulating machinery are fly-wheels, which are nothing more than large heavy wheels driven with great velocity by the machinery to which they are attached. One of these wheels is shown at W. in Plate CCXXXIX. Fig. 192. and others will be seen in our plates illustrative of the article on the STEAM ENGINE.

When a fly-wheel is put in motion it derives a very high momentum from its great weight and velocity, and may therefore be regarded as a sort of reservoir of power, by which the machine is supplied with velocity whenever there is any defalcation in the moving power, any intervals of rest arising from the nature of the machinery, or any inequality of resistance arising from the nature of the work to be performed. In the single steam engine, for example, while the piston is descending, and when no impelling power is exerted, the momentum of the fly keeps up the rotatory motion of the machinery till the impelling force is again exerted during the ascent of the piston. In Vauloue's pile engine, when the resistance is suddenly removed, the horses are prevented from falling solely by the momentum of a heavy fly-wheel, against which their force is exerted till the ram or weight is again raised. Fly wheels are sometimes made with vanes, which regulate the descent of a weight by the increased resistance of the air; but they are not much used in machinery.

SECT. II. *On Contrivances for preventing irregularities in the Motion of Machines, by regulating the variable actions of the First Movers.*

Although a fly-wheel is capable of counteracting the effects of unavoidable variations in the impelling power, yet it is always preferable to prevent these variations when it can be done by regulating the action of the first mover. The inventions which have been employed for this purpose exhibit much ingenuity, and merit the attentive study of the engineer. One of the most ingenious of them is certainly the condenser of forces invented by M. Prony, which we shall describe in his own words.

1. *Prony's Condenser of Forces.*

"Any machine being constructed, to discover, without making any change in the construction, a method of transmitting to it the action of the first mover by fulfilling the following conditions, namely,

1*st*, That it may be possible at pleasure, and with great speed and facility, to vary the resistance against which the effort of the first mover must continually make an equilibrium in limits of any required extent.

2*d*, That the resistance being once regulated, shall be rigorously constant until the moment when it is thought proper to increase or diminish the same.

3*d*, That in the most sudden variations of which the effort of the first mover may be capable, the variation in velocity of the machine shall never undergo a solution of continuity.

M. Prony applies his solution of this problem to the dynamic effect of wind, but it will be easy to apply it when other first movers are used.

In the section and plan of the machine, exhibited in Plate CCCLXVII. Fig. 1. and 2. OO represents the vertical arbor to which windmill sails are adapted, *e e e e* is an assemblage of carpentry, of which one of the radii O *e* carries a curved piece *b d* of iron or steel; vertical axes of rotation, *a a a* being placed round the axis OO, also divide the circumference in which they are found into equal parts.

Each of these axes carries a curve *a f* of iron, steel, or copper, so situated, that when the wind acts upon the sails, the curve *b d* presses against one of the curves *a f*, and causes the vertical axis to which this last curve is fixed to make a part of a revolution.

The curves *b d* and *a f* must be so disposed, that when *b d* ceases to press on one of the curves *a f*, it shall at the same instant begin to act upon the following curve. The number of axes which are provided with these curves must be determined by the particular circumstances of each case; and it is also practicable to substitute instead of *b d* a portion of a toothed wheel having its centre in the axis OO, and to place portions of pinions instead of the curves *a f*, but the dispositions represented in the figure are preferable.

Each of the axes *a a a a* (which are all fitted up alike, though, for the sake of clearness, only one of them has its apparatus represented in the Figures,) carries upon it a drum or pulley *t t r r*, on which is wound a cord that passes over a pulley *p*, and serves to support a weight Q by means of the lever FG, upon which this weight may slide, and be fastened at different distances from the centre of motion G.

The same axes *a a* pass through the pinions *q q*, to which they are not fixed; but these pinions carry clicks or ratchets which bear against the teeth *r r*, so that when the weight Q tends to rise, the ratchet gives way, and no other effect is produced on the pinion *q q*, either by the motion of the axis or of the drum *t t r r*, excepting that which causes the ascent of the weight *q q*, but the instant that the curve or tooth *b d* ceases to bear against one of the curves *a f*, after having caused the corresponding weight Q to rise, that weight Q tends to redescend, and then the toothed wheel *r r* acts against the ratchet, so that Q cannot descend without turning the pinion *q q* along with the drum *t t r r*.

The pinion *q q* works in the wheel *a b*, from the motion of which the useful effect of the machine immediately arises; so that the effect of the descent of one of the weights Q is to put the wheel AB in motion, or to continue the motion in concurrence with all the other weights Q which descend at the same time. The wheel AB carries beneath it oblique or bevelled teeth CD, which work in a like wheel CE, and cause the buckets at P to rise.

From the preceding description it will be seen, that the machine being supposed to start from a state of rest, the wind will at first raise a number of weights Q sufficient to put the machine into motion, and will continue to raise new weights, while those before raised are fallen, so that the motion once impressed will be continued.

Among the numerous advantages of this new mechanism, are the following:

1*st*, No violent shock can take place in any part of the mechanism.

2*d*, The useful effect being proportioned to the number of weights Q, (Plate CCCLXVII. Fig. 4.) which descend at the same time, this effect will increase in proportion as the wind becomes stronger and causes the sails to turn with greater velocity.

The weights Q being moveable along the levers FG, it will always be very easy to place them in such a manner as to obtain that ratio of the effort of the first mover to the resistance, which will produce a maximum effect.

From this property it follows, that advantage may be taken of the weakest breezes of wind to obtain a certain product, in circumstances under which all other windmills are in a state of absolute inactivity. This advantage is of great importance, particularly with regard to agriculture; the windmills employed for watering land are sometimes inactive for several days, and this inconvenience is more particularly felt in times of drought. A machine capable of moving with the slighthst breeze must therefore offer the most valuable advantages." See *Annales des Arts et Manufactures*, tom. xix.

2. *Watt's Conical Pendulum or Governor.*

This ingenious apparatus was invented by the late Mr. James Watt, for regulating the admission of the steam into the cylinders of his engines. It consists of a perpendicular axis QF (see Plate CCCXXI. of Hydrodynamics, Fig. 5. which contains a view of it when applied as a sluice-governor,) put in motion either by a wheel and piston R, Q, or by a belt passing round the pulley I. Two heavy balls G, H, are applied to this axis by means of two rods EG, EG, which cross one another above E, in a mortise formed in the upper part of the axis. (This is not shown in the Figure, but will be fully represented in our Plates of the Steam Engine.) These two rods, after crossing each other, are bent outwards in a contrary direction, and to them are jointed two short pieces, the other ends of which join to a collar, capable of sliding up and down on the upper part of the axis, forming altogether an assemblage resembling the joints of tobacco tongs or lazy scissars, (See Plate CCCLXVI. Fig. 23.) so that when the balls recede, which always happens when the centrifugal force arising from an increase of velocity of the main shaft increases, the collar is depressed, and when the balls approach the axis, which takes place when the centrifugal force diminishes, the collar rises, and by its action upon a double ended lever, which is connected with an arm fixed upon the spindle of the throttle valve, more or less steam is admitted into the cylinder.

3. *Burn's Sluice Governor for regulating the introduction of water into water wheels.*

This contrivance has already been described at full length in our article Hydrodynamics, and represented in Plate CCCXXI. Fig. 5. An analogous contrivance, invented by Mr. Quayle, will be found in the *Transactions of the Society of Arts*, vol. xi. and in Gregory's *Mechanics*, vol. ii. p. 273.

4. *Mr. Samuel's contrivance for regulating the action of horses when driving machinery.*

This contrivance was invented by Mr. Walter Samuel, smith at Niddrey, Linlithgowshire, and is now in actual use in many thrashing-mills in Scotland. It is represented as applied to a thrashing machine driven by four horses in Plate CCCLXVII. Fig. 3. and to a machine driven by six horses in Fig. 4.

In Fig. 3. which is a plan of the perpendicular axle and levers, A, A represent the axle or shaft, in which are fixed the levers or arms, B, B, B, B, that carry the great wheel, and by which the machine is turned round when working.

C, C are two frames fixed in the axle A, and supported by the arms B. Upon these frames are placed the two shifting-blocks 11 and 14, which are easily moved either inward to the axle A, or outward from it. In each of these shifting-blocks are placed two running sheaves.

D, D an endless rope or chain, which passes over the two sheaves that are placed in the shifting-blocks at the ends 12 and 13. By this rope the blocks are so connected, that when one is pulled outward from the axle A, the other is pulled inward alternately.

E, E are two sheaves by which the rope D, D is kept clear of the axle A, when turning round.

E, F and E, F are ropes which pass over the sheaves that are placed in the shifting-blocks at the end 11 and 14. Upon each end of the ropes F, F, is fastened a small block, in which are placed the running sheaves G, G, G, G, and over these sheaves pass the double ropes, by which the horses pull when working this machine.

H, I, K, L, M, N, and O, P, represent the limbers, which are fixed with screw-bolts, near the extremity of the arms B, B. In each of these limbers are placed two running sheaves, which conduct the ropes with their hooks to the line of draught.

Each horse is yoked to two hooks, as 1, 2, 3, 4, 5, 6, 7, 8; which are fastened on the ropes that pass over the sheaves, G, G, G, G; the sheaves having liberty to turn on their axle. By this means the draught will always press the collars equally upon the horses' shoulders, whether they incline to pull outward from the centre of their walk, or inward to that centre. And, therefore, though the horses are walking in a circle, yet the strain of the draught must press fair on their shoulders, without twisting to either side. This advantage cannot be obtained in the ordinary way of yoking the horses in a thrashing machine, unless the draught-chains, on each side of the shoulders, be made in exact proportion to the diameter of the circle on which they walk; or the chain next to the centre of their walk made a degree shorter than the one farthest from it, which is often neglected.

The draught-ropes being thus all connected by the endless rope D, D, and the shifting-blocks having liberty to move, either inward to the axle A, or outward from it; it follows, that if one of the horses relax, the other horse must immediately press the collar to his shoulders, and by this means he is excited to exertion. For instance, if the horse yoked to the hooks at 1, 2, were to relax; then the one yoked at 5, 6, would instantly take up his rope, and pull the collar close to his shoulders, so that the horse, at 1, 2, must either exert himself, or be pulled backward. And supposing the horses at 1, 2, and 5, 6, both to relax, then the exertions of the horses at 3, 4, and 7, 8, would pull the shifting-blocks from 11 toward 14, which would tend to drag the horses at 1, 2, and 5, 6, backward, and force them to exertion: So that each horse spurs up his companion in consequence of being all connected by the ropes and shifting-blocks. Thus the exertion of all the horses completely round the circle is united, so as to form one power applied to the machine, instead of as many independent powers as there are horses employed.

As it may sometimes be convenient to employ fewer horses than the whole number of which the machine admits, this is provided for, so as still to unite the power of the horses that are employed. Upon the rope F is fastened an iron hook, which is hooked into the eye of a bolt fixed in one of the arms, as at R, and thus the horse at 7, 8, is left out of the circle, whilst the power of the horses at 1, 2; 3, 4; 5, 6, are still united.

In Plate CCCLXVII. Fig. 4. which is a plan of the perpendicular axle and levers of a thrashing machine driven by six horses, A is the axle in which are fixed the arms B, B, B, B, B, B, which carry the great wheel, and upon these arms are fixed with screw-bolts the limbers, in each of which are placed two sheaves, that conduct the draught-ropes or chains to the line of draught.

C, D, E, are three frames fixed in the axle A, and supported by the arms B. Upon each of these frames are placed a shifting-block 1, 4, 6, having freedom to move either inward to the axle A, or outward from it. Into each of these shifting-blocks are placed two running sheaves, over three of which pass the endless rope or chain 7, 8, 9. Thus the three blocks with their sheaves are so connected, that if any one is pulled outward from the axle A, the other two blocks must shift inward.

There is also a rope which passes over each of the sheaves that are placed in the shifting-blocks at 1, 4, 6. And upon the ends of these ropes, at 10, 11, 12, 13, 14, and 15, are fastened a small block with a running sheave in each, and over these sheaves the ropes or chains pass, by which the horses pull or draw, when working the machine.

F, G; H, I; K, L; M, N; O, P; and Q, R, represent the limbers fixed on the arms B, with screwed bolts. Into each of these limbers are placed two running sheaves, which direct the ropes 10, 11, 12, 13, 14, and 15, to the line of draught.

Each horse is yoked to these ropes by the hooks at S, T, U, V, W, and X. Thus, by the endless chain, shifting-blocks, and running sheaves, all the ropes by which the horses pull are connected, and of course the power of all the horses is united, whatever number may be employed. This apparatus will apply to two horses, or to any greater number that may be found necessary.

See Mr. Samuel's pamphlet, entitled "*Account of a New Apparatus for Yoking Horses in Thrashing Machines*," Edin. 1811, from which we have taken the preceding descriptions; also the *Farmer's Magazine*, Vol. XI. p. 492. and Vol. XIII. p. 279.

5. *Account of Mr. Gray's Method of regulating the Velocity of Wind-Mills.*

It is well known to those whose thrashing machines are driven by horses, that this is by far the most severe part of farm-labour in which these useful animals are employed. It would therefore be very desirable, if thrashing machines could always be turned by some natural power, as water, wind, or steam; there are, however, but few farms on which a fall of water can be obtained; and as to steam, the expense of fuel, in general, will no doubt prevent in a great measure this power from being employed. Wind therefore seems to be the most eligible power for that purpose, because it can be obtained in every place without any expense, and is generally to be had at that season of the year when thrashing is most needful, and may be used both at night and day: Mr. Andrew Gray has therefore very ingeniously suggested, that in place of the great length of oars, covered with canvas, a wheel with wooden vanes might be constructed, so as to regulate the effect of the wind upon the vanes, and at the same time have sufficient power to drive any ordinary machine. The method which Mr. Gray proposes for regulating the vanes is, to have a hole in the centre of the axle, through its whole length, and in this opening to place a rod of iron, extending several feet without the axle at each end. Upon the end of this rod which faces the wind is placed a tube of cast metal, about one foot in length, and in it the rod must have liberty to revolve. At each end of this tube is a small hole through the axle, to receive a wedge or bolt, to prevent the tube from shifting endways on the rod; upon the axle are fixed several arms, and on these arms are fastened two wheels, one near their extremity, and the other two or three feet from the centre of the axle. Between these two wheels are placed the vanes, which may be of any number, according to the diameter of these wheels, and the power required to drive the machine, but the vanes ought to be placed at a considerable distance from one another; and in order that they may be easily set to the most proper angle, or the best position to receive the wind, there is fixed, near one edge, and upon each end of every vane, an iron pivot, which turns on brass cods, fixed in the inner edge of the greater wheel, and the outer edge of the smaller one. Upon each end of the metal tube, on the iron rod that goes through the centre of the wind-wheel axle, there is a fledge or rim, and in these fledges there must be the same number of holes as there are vanes in the wind-wheel; and in each of these holes is placed one end of a small rod of iron, the other end of which is attached by a hinge to the farthest off edge of each vane. By this means all the vanes are connected with the metal tube, on the end of the iron rod that goes through a hole in the centre of the wind-wheel axle, in the other end of this rod is cut a number of teeth, which work in the teeth of a small pinion, which is fixed upon an iron axle, and on this axle is also placed a wheel of iron, having teeth, which take into the links of an iron chain, and to this chain is suspended a weight. When the wind is too strong, the farthest edges of the vanes are forced backward, as they have liberty to turn on their pivots, and then the vanes present a less surface to the wind; at the same time the iron rod which passes through the axle of the wind-wheel is also pushed back by the small iron rods attached to the vanes, and the last metal tube on the end of the centre rod; then the teeth of this rod, by taking upon the teeth of the small pinion on the axle of the chain-wheel, causes this wheel to be turned round, and of course the weight attached to the chain is raised up; and so soon as the wind abates, then the weight by its chain pulls this wheel round, and the small pinion fixed on the same spindle, pushes the centre rod with the tube on its fore-end outwards; and this tube, by the small iron rods, pulls the vanes more to face the wind, by which means the vanes are placed at any angle, and the velocity of the wind-wheel must be in a great measure regulated according to the strength of the wind. It is doubtful if this method will answer well in a large machine, but it may be very useful on a small scale.

6. *Contrivance for Regulating the Motion of Millstones.*

This contrivance, represented in Plate CCCLXVII. Fig. 5. is an application made in this country of Mr. Watt's conical pendulum to mills for grinding corn. The moveable millstone A is in windmills generally turned from above. It is placed upon an axis *a b*, which rests upon the bush C, fixed upon the beam DE. Round the axis *a b* is fixed a ring *f g*, which carries four arms for receiving the rods of four iron balls *h*, *i*, *k*, *l*, each of which weighs about 5 pounds. From the upper ends of these rods descend four other rods which support the piece F, which can slide freely up and down the axis *a b*. In the piece F is cut a groove for receiving the extremity of the lever *d e*, cut in the form of a fork, and whose other extremity *m* supports the plank DE, which turns upon the centre *n*. When the upper millstone A is put in motion, the whole system of iron balls will revolve along with it; and in proportion as the velocity of the wind increases that of the millstone, the balls will deviate from the axis by the increase of the centrifugal force; the piece F will descend; the lever *d e m* will be forced into the part *d*, and will raise by the end *m* the plank DE, and consequently the upper millstone A. See Lanz and Betancourt's *Essai*, &c. p. 84. Other contrivances for the same purpose will be seen in Bockler's *Theatrum Machinarum*, and in Ramelli's *Le Diverse et Artificiose Machine del Capitano Agostino.*

7. *Wolff's Substitute for a Fly.*

The following apparatus, shown in Plate CCCLXVII. Fig. 6. was invented by Mr. Wolff as a substitute for the fly in steam engines. It has the advantage of equalizing the motion, while it can be stopped and set to work at any part of the stroke. The beam of the steam engine is shewn at A, the connecting rod at B, the crank arm at C. The cog-wheel D works into another cog-wheel E of half the size, and F is a crank arm on the shaft of the small wheel, which crank is connected with a solid unperforated piston, that works in the cylinder G, closed at bottom, and thus leaves a vacuum beneath. This acts simply as a weight on the crank F, by the constant pressure of the atmosphere. The diameter of the piston must be made such as nearly to equal one-third of the power of the engine. The outer circle in the annexed figure, (Plate CCCLXVII. Fig. 7.) is the line described by the crank. The circumference of the inner circle is equal to twice the diameter of the outer, and the square has the same circumference. This last exhibits the inequality still remaining, which by this method is reduced to about one-fifth; but by the assistance of a small fly on the second motion, the effect will become nearly the same as that of a rotative engine, with the advantages already mentioned. The same contrivance is applicable to a pump; but the two cranks must in this case be horizontal at the same time. See Nicholson's *Journal*, No. 23. new series.

8. *Description of the Fusee for regulating the Action of Springs.*

When the elastic force of a spring, coiled up as at OP, (Plate CCCII. Fig. 1.) is the first mover of machinery, as in the case of watches, &c. it is obvious that the force which it exerts in uncoiling itself, is a maximum at the commencement of its action, and gradually diminishes as it uncoils itself. In order to regulate this variable force, a contrivance called the Fusee is adapted to it. It is represented in Plate CCCVI. Fig. 1. where A is the box containing the spring; S a chain fixed upon the circumference of that box, and passing round the fusee OI, the diameter of which gradually varies from its upper to its lower surface, in consequence of its having the form of a spiral, as shown in the figure. When the spring is coiled up, which is the case shown in the figure, its force is a maximum; and, therefore, in conveying its force, by means of the chain S, to the fusee, it acts by a lever equal to the smallest radius of the fusee. As it uncoils its power diminishes, and the lever by which it acts gradually increases; so that the varying intensity of the force exerted by the spring is regulated by the varying length of the lever by which this force is applied to the machinery. For an account of the method of forming the fusee, see Varignon *De la Figure des Fusées des Horloges à ressort*, in the *Mem Acad. Par.* 1702, p. 122.; and De La Hire's *Traité de Mecanique*, Prop. lxxiii. p. 321.

SECT. III. *Contrivances for preventing Irregularities in the Motion of Machines, arising from the Nature of the Machinery.*

In raising minerals, or heavy bodies, from very great depths, it is often necessary to counterbalance the ropes or chains by which the buckets are suspended. This may be done by a conical drum or a fusee; but it is commonly effected by a counterweight, which consists in a small chain attached to the arbor of a drum, and which, after passing over a pulley into the pit, suspends a very heavy chain at its extremity. When the two cables or chains are balanced, the large chain is heaped up at the bottom of the pit; but, in proportion as the difference of the weights of the cables increases, the small chain, winding itself round the arbor of the drum, raises the large chain which is suspended through all its length, when one of the buckets arrives at the top of the pit. The following contrivances are intended as substitutes for these methods.

1. *Mr. Featherstonhaugh's Contrivance for supplying the place of Counterweights.*

Let A, (Plate CCCLXVII. Fig. 8.) be a drum driven by a steam engine, or any other power, and let X, V be the cables which descend into the mine, in order to suspend and raise the buckets. When the machine is at work, the drum A turns round its axis, and turns the wheel G by the pinion E; so that the chain C, which carries the weight W, rolls in a groove upon the curves KK, firmly fixed to an arm of the wheel G. When the wheel G is turned so that the chain makes a right angle with the arm V, the weight W acts with the greatest force, and the difference of the weights of the cables is a maximum. The curves KK should have such a form, that, when the wheel G is in motion, all the perpendiculars drawn from its centre upon the line of direction of the chain should increase uniformly. A weight x is attached to the rim of the wheel G, in order to be a counterpoise to the weight of the curves KK.

2. *Variable Counterweights.*

Numerous contrivances have been invented for the purpose of variable counterweights, or, what amounts often to the same thing, for obtaining a measure of variable forces. A great variety of these have been described in our article ANEMOMETER, and represented in Plates XXVIII. and XXIX. One of the best and most accurate of them is shown in Plate XXIX. Fig. 12. and operates by the variable weight of a hollow cylinder of metal, which is more or less immersed in a fluid.

Another variable counterweight is represented in Plate CCCLXVII. Fig. 9. It consists of several cylindrical weights connected together by rods *a*, *a*, which return into one another, and pass over the cross pieces *b b*. These rods are not in the same plane as shown in the section, Fig. 5.; so that, when the rope R is raised, it is at first stretched only by one of the weights. By raising it more, it supports two of the weights, and so on. In like manner, after all the weights are suspended by the rope R, when this rope begins to descend the lowermost ceases to act upon the rope, in consequence of the rod *a a* belonging to it slipping up from the cross bar *b b*, which supported it. As the rope descends, the next weight rests upon the lowermost, and the rope is freed from its weight, and so on with all the rest. These weights are obviously variable in regular arithmetical progression, the weights by which the tension of the rope is increased or diminished being proportional to the quantity of the rope coiled or uncoiled, or to the descent or ascent of any part of the rope. If it be required that the tension of the rope should diminish according to any other law, we have only to increase or diminish the diameter of the weights according to that law, and allow their heights to remain the same. A counterweight of the same kind as the preceding is formed by a chain with heavy links, or by a number of weights connected together by a rope. An anemometer, in which the variable velocity of the wind is measured by a variable counterweight of this kind, was invented and used by the late Mr. Kirwan. In counterweights of this kind, however, each weight is the smallest quantity which can be measured; so that they cannot be of any use in delicate machinery, where accurate results are expected.

3. *Compound Cranks.*

If any machine is to be driven by the intervention of one or more cranks, which, from their very motion, have an irregular action, the irregularity may be diminished within certain limits, by the arrangement of the cranks themselves, as we have already described in p. 660.

CHAP. V.

On Friction.

The word Friction properly signifies the act of one body rubbing upon another; but in mechanics it is employed to denote the degree of retardation, or of obstruction to motion, which arises from one surface rubbing upon another. If we place a heavy body upon a surface perfectly level, it is not in a state of equilibrium between all the forces which act upon it, otherwise it would move by the application of the smallest force, in a direction parallel to the plane. Its friction upon the level surface is the unbalanced force which occasions this want of perfect equilibrium; and if a new force of equal magnitude is applied, so as to balance that force in any given direction, the body will obey the least impulse in that direction, and the force thus employed will be an exact measure of the retarding force of friction. "Friction," as Mr. Playfair has justly remarked, "destroys, but never generates motion, and in this is unlike gravity, or any of the forces hitherto considered, which, if they retard motion in one direction, always accelerate it in the opposite. The force of friction, therefore, violates the law of continuity, and cannot be accurately expressed by any geometrical line, or any algebraic formula." "Though friction destroys motion, and generates none, it is of essential use in mechanics. It is the cause of stability in the structure of machines, and is necessary to the exertion of the force of animals. A nail, or screw, or a bolt, could give no firmness to the parts of a machine, or of any other structure, without friction. Animals could not walk, or exert their force anyhow, without the support which it affords. Nothing could have any stability but in the lowest possible situation; and an arch which could sustain the greatest load when properly distributed, might be thrown down by the weight of a single ounce, if not placed with mathematical exactness at the very point which it ought to occupy."*

As a knowledge of the nature and effects of friction, and of the method of diminishing its influence in machinery, is of the first importance in practical mechanics, we shall offer no apology for treating the subject at considerable length.

The subject of friction has occupied the particular attention of many distinguished individuals, particularly Amontons, Bulfinger, Parent, Euler, and Bossut; but though their writings contain much important information, and many ingenious views, yet it was reserved for the celebrated Coulomb to give an accurate and satisfactory investigation of this difficult branch of practical mechanics. By using bodies of a large size, he has corrected the errors of preceding writers, and discovered many new and valuable facts, which had escaped the notice of his predecessors. His Memoir on this subject gained the double prize offered by the Academy of Sciences in 1779 and 1781, and was published in the *Memoires des Sçavans Etrangers*, tom. x. p. 163—333. At a later period of his life, he resumed the inquiry, and brought to light some new and important facts, which were published in the memoirs of the Academy for 1790, under the title of *Mémoire sur le Frottemens de la Pointe des Pivots.*

In pursuing this subject, we shall consider—

1. The Friction of Surfaces.
2. The Friction of Axles.
3. The Friction and Rigidity of Ropes.
4. The Friction of Pivots; and
5. The Means of diminishing Friction in Machinery.

Sect. I. *On the Friction of Surfaces.*

In examining the friction of surfaces, M. Amontons found that it was exactly proportional to the weight of the moving or rubbing body, and was in general equal to *one-third* of the weight with which it was pressed against the surface over which it moved. He found also that the resistance did not increase with an increase of the rubbing surfaces, nor with the velocity of the body.

M. Bulfinger obtained results nearly similar to those of Amontons, but he made the resistance of friction equal only to *one-fourth* of the force with which the rubbing surfaces were pressed together.

M. Parent, considering friction as caused by small spherical eminences in one surface, being dragged out of small spherical cavities in the other, proposed to determine the quantity of friction by finding the force which would move a sphere standing upon three equal spheres. This force he found to be to the weight of the sphere as 7 to 20, or to be $\frac{1}{2.855}$ of the sphere's weight. In his experiments on friction, M. Parent placed the body upon an inclined plane, the inclination of which he increased or diminished, till the body had a tendency to move, and the angle at which the motion commenced he called the angle of equilibrium. The weight of the body was therefore to its friction upon the inclined plane as radius to the sine of the angle of equilibrium; and its weight was to the friction on a horizontal plane as radius to the tangent of the angle of equilibrium.

The celebrated Euler considered the ratio between friction and the force of pressure to be as 1 to 4. He observes, that when a body is in motion, the friction will be only one-half of what it is when the body has begun to move; and he shows, that if we gradually augment the inclination of an inclined plane, till the body which is placed upon it begins to descend, the friction of the body, at the commencement of its motion, will be to its pressure against the plane as the sine is to the cosine of the plane's inclination, or as the tangent of the plane's inclination is to radius. But when the body is in motion, the friction is diminished, and may be found by the formula,

$$F = \text{Tang. } A \times \frac{M}{15265\, n^2 \times \cos. A},$$

in which F is the friction, the weight or pressure of the body being unity; A the inclination of the plane; *m* the length of the plane in 1000th parts of a Rhinland foot, and *n* the time of the body's descent. In explaining the cause of friction, Euler regards the eminences and depressions as angular, and he supposes the friction to arise from the perpetual ascent of a number of inclined planes.

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* Playfair's *Outlines of Natural Philosophy*, Vol. I. p. 94, 105. &c. Second Edition

The Abbe Bossut* has distinguished friction into two kinds, viz. that which is generated by one surface rubbing upon another, and that which arises from one body turning or rolling upon another. The circumference of a wheel rolling on the ground is an example of the first of these, and the friction of the axle of a wheel in motion is a combination of the two kinds of friction. M. Bossut agrees with Amontons in his opinion, that an increase of surface does not occasion an increase of friction. He took a rectangular parallelopiped of wood, weighing 51 lbs. and having dragged it over a horizontal table, and loaded it with different weights, he found, that though one of its surfaces was *five* times greater than the other, the same force was capable of putting the body in motion, whether it rested on the large or the small base. Muschenbroek, and other writers, maintained that the friction increased with the surface.

Bossut has remarked two very important facts on the subject of friction; namely, that the friction is affected by the time in which the surface remains in contact, and that it does not follow exactly the ratio of the pressures. He found that when the surfaces had been for some time in contact, their friction increased, either in consequence of a greater number of eminences having entered into the corresponding cavities from a continuance of the pressure, or from some physical cause which united the two surfaces more firmly together. Bossut likewise noticed, that in large masses the friction is a less part of the pressure than in small masses; but he does not seem to have observed, that this arose from the greater velocity which the mass derived from its magnitude. "Ship-builders," he observes, "give only a declivity of from 10 to 12 lines in a foot to the inclined planes upon which vessels are launched. But this declivity, which is sufficient for putting large masses in motion in spite of the resistance of friction, is too small for weights of a moderate size." Bossut, however, seems to have suspected, that friction might diminish as the velocity increased, when he says, "that if it happens on one hand, that in proportion as the velocity increased, there are more points to disengage, or more springs to bend; yet it may happen, on the other hand, *that this same velocity does not give to the pressure time to permit the points to enter the cavities so deeply as they would be allowed to do if the velocity were less.* But a diminution of this depth ought to produce a diminution of friction.

The Rev. Dr. Vince of Cambridge found, that the friction of hard bodies in motion is an uniformly retarding force, and that the quantity of friction F, considered as equivalent to a weight drawing the body backwards, is $F = M \times \frac{M \times W \times S}{g t^2}$, where M is the moving force expressed by its weight, W the weight of the body upon the horizontal plane, S the space through which the moving force or weight descends in the time t and g, the force of gravity, or 16.087 feet. Dr. Vince likewise found, that the friction increases in a less ratio than the weight of the body, and that the smallest surfaces of the same body have the least friction.

The experiments of Coulomb on the friction of surfaces, were made with the apparatus which we have described in Part III. Chap. I. of the present article, and by means of it he obtained the following results;

1. *Friction of one wood upon another.*—When the bodies rubbed upon one another *in the direction of the fibres*, after they had remained in contact for *one* or *two* minutes, he obtained the following mean results:

	Friction in parts of the weight.		Friction in parts of the weight.
Oak against oak	$\frac{1}{2.34}$	Fir against fir	$\frac{1}{1.78}$
Oak against fir	$\frac{1}{1.50}$	Elm against elm	$\frac{1}{2.18}$

When oak rubbed upon oak, and when the touching surfaces were reduced to the smallest possible dimensions, the friction was $\frac{1}{2.36}$, $\frac{1}{2.42}$, $\frac{1}{2.40}$.

When the friction is *across the grain, or at right angles to the direction of the fibres.*

Oak against oak was $\frac{1}{3.76}$.

The preceding ratios are constant quantities, which do not depend upon the velocities, excepting in the case of elm, when the pressures are very small, for in that case the friction sensibly increases with the velocity.

2. *The Friction increases with the time of Contact.*—When wood was moved upon wood in the direction of the fibres, the friction gradually increased, and reached its *maximum* in 8 or 10 seconds. When the friction was across the grain of the wood, a longer time elapsed before it reached its maximum.

3. *Friction of metals upon metals after a certain time of rest.*—The following experiments were made with two flat rulers of iron, 4 feet long and 2 inches wide, attached to the fixed plank of the apparatus. Other four rulers, two of iron and two of brass, 15 inches long, and 18 lines wide. All the angles of these rulers were rounded off, and the rubbing surfaces of the rulers were 45 square inches.

	Pressure.	Friction in parts of the pressure.		Pressure.	Friction in parts of the pressure.
Iron upon iron	53 lbs.	$\frac{1}{3\ 5}$	Iron upon brass.	52 lbs.	$\frac{1}{4\ 2}$
	453	$\frac{1}{3.6}$		452	$\frac{1}{4.1}$

In these experiments the friction is nearly the same in each set, although the pressures are to one another nearly as 9 to 1. Hence it follows, that in metals the friction is independent of the extent of the rubbing surfaces. Coulomb found also, that in this case the friction is independent of the velocities.

The ratio of 4 to 1, between the pressure of friction in the case of iron moving upon brass must not be considered as exact, unless in the case when the surfaces are new and very large. When the surfaces are diminished till they become very small, the ratio varies from 4 to 1 to 6 to 1, but it does not reach this last ratio unless when the friction has been continued for more than an hour, when the iron and brass have taken the highest polish of which they are susceptible, free of all scratches.

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* *Traité de Mécanique*, Part I. Chap. IV. Sect. I. p. 178, Edit. 1802. These observations of Bossut were first published in 1763, and with some slight additions in 1775, before the appearance of Coulomb's Researches.

4. *Friction of Oak upon Oak when greased with Tallow, and the Tallow renewed at every experiment.*

	Pressure.	Friction in parts of the pressure.		Pressure.	Friction in parts of the pressure.
Oak against oak	3250 pounds	$\frac{1}{27.6}$	Oak against oak	450 pounds	$\frac{1}{21\ 5}$
	1650 —	$\frac{1}{25\ 8}$		250 —	$\frac{1}{18.5}$
	850 —	$\frac{1}{23.6}$		50 —	$\frac{1}{7.7}$

The very remarkable increase of friction which takes place in the preceding results by a diminution of pressure, is ascribed by Coulomb to the cohesion of the parts of the tallow, and to the extent of the rubbing surfaces. If this cohesion is the principal cause, then it is obvious that the constant resistance which it produces, must have had very little effect in the experiment 1st; and therefore Coulomb regards the ratio of $\frac{1}{27.6}$, as expressing the real relation between the friction and the pressure in all the rest, but particularly in experiment 6th. Since the friction, therefore, *plus* the cohesion, gives a resistance of 6.5, with a pressure of 50 lbs. or a friction of $\frac{1}{7.7}$, the resistance is composed of a friction $= \frac{50\text{ lbs.}}{27\ 6}$ or 1.8 lb. and of a cohesive force $= 6\ 5$ lb. — 1.8 = 4.7 lb. Taking as an even number 5 lbs. as a measure of this cohesion, we shall have 28.3 for the mean and approximate value of the ratio of pressure to friction, when corrected, for the resistance arising from the cohesion of the tallow.

When the touching surfaces were reduced from their original magnitude of 180 square inches, to *one sixth*, or about 30 square inches, the preceding ration of $\frac{1}{27\ 6}$ is reduced to $\frac{1}{16}$ or $\frac{1}{17}$. The velocity appeared to have an influence on the results in this kind of friction.

5. *Influence of the time of contact upon the Friction of Oak upon Oak, when greased with Tallow, renewed at every experiment.* In the following very interesting experiments, the surface of contact was 180 inches.

Pressure.	Time of contact.	Friction in parts of the pressure.
47 pounds.	0 minutes	$\frac{1}{7.7}$
	4 minutes	$\frac{1}{5.87}$
	2 hours	$\frac{1}{5.25}$
1650 pounds.	0 seconds	$\frac{1}{25\ 8}$
	3 seconds	$\frac{1}{10.3}$
	15 seconds	$\frac{1}{7.9}$
	1 minute	$\frac{1}{5.82}$
	4 minutes	$\frac{1}{5.29}$
	2 hours	$\frac{1}{3.65}$
	6 days	$\frac{1}{2.65}$

Pressure.	Time of contact.	Friction in parts of the pressure.
3250 pounds.	0 seconds	$\frac{1}{27.08}$
	3 seconds	$\frac{1}{10.16}$
	15 seconds	$\frac{1}{9.16}$
	1 minute	$\frac{1}{7.87}$
	4 minutes	$\frac{1}{5\ 48}$
	1 hour	$\frac{1}{3.7}$
	2 hours	$\frac{1}{3\ 53}$
	5 days	$\frac{1}{2\ 66}$ $\frac{1}{2.09}$

In the preceding experiments the tallow was new, but in the following it had been laid on, and used for some time, and was not renewed during the experiments.

Pressure.	Time of contact.	Friction in parts of the pressure.	Pressure.	Time of contact.	Friction in parts of the pressure.
2310 pounds.	0 minutes	$\frac{1}{12.3}$	5810 pounds	4 minutes	$\frac{1}{6.71}$
	2 minutes	$\frac{1}{5.9}$		9 minutes	$\frac{1}{6.12}$
	1 hour	$\frac{1}{5\ 12}$		26 minutes	$\frac{1}{5.6}$
	16 hours	$\frac{1}{4.5}$		1 hour	$\frac{1}{4.9}$
5810 pounds	0 minutes	$\frac{1}{11.57}$		16 hours	$\frac{1}{3.8}$
	2 minutes	$\frac{1}{7.35}$			

As this last experiment was made with particular care, Coulomb endeavoured to deduce from it the law of the increase of friction. Assuming the formula $F = A + mT\mu$, where A is the weight (in this case 502 lbs.) equal to the friction when the velocity is insensible, m a constant co-efficient, and $T\mu$ the time of rest, which has preceded the experiment raised to the power μ. In this way he finds μ to be $\frac{1}{5}$. Hence $F = 502 + m\ T\frac{1}{5}$. In order to find m from the experiment, after 4′ rest, we have $m\ T\,\frac{1}{5} = 364$ lbs; and as $T = 4'$, we have $m = \frac{364}{(4')}\,\frac{1}{5}$ lbs.

The above formula can only be used when the time of rest is very short; for it is obvious that if F could be exactly expressed by $A + mT\mu$, however small be the quantity μ, then, when T became infinite, F would become infinite, which cannot be, as the friction attains its maximum after a finite time.

This new condition may therefore be satisfied by the formula $F = \frac{A + m\,T\mu}{C + T\mu}$, which, when $T = 0$, gives $F = \frac{A}{C}$, and when T is infinite, gives $F = \mu$.

6. *Friction of Iron upon Brass, and Iron upon Iron, when greased.*

	Pressure.	Time of contact.	Friction in parts of the pressure
Brass upon Iron	50 pounds.	0 minutes .	$\frac{1}{8.33}$
		4 minutes .	$\frac{1}{7.14}$
		30 minutes .	$\frac{1}{7.14}$
	450 pounds.	0 minutes .	$\frac{1}{10.7}$
		4 minutes .	$\frac{1}{9.37}$
		2 hours .	$\frac{1}{9.37}$
	1650 pounds.	0 minutes .	$\frac{1}{11}$
		3 minutes .	$\frac{1}{10.4}$
		4 hours .	$\frac{1}{9.8}$
		4 days .	$\frac{1}{9.8}$

The excess of the friction under a pressure of 50 lbs obviously arises from the cohesion of the tallow, which amounted to 1½ pounds, which makes the friction $\frac{1}{11}$ when the time of contact was 0, and 9.5 when it had reached its maximum.

The following experiments were made under different circumstances.

In order to prepare the metals for these experiments, which was found absolutely necessary before regular results could be obtained, they were first polished as highly as possible, and, after being greased with oil or tallow, they were attached to the sledge, and made to rest upon one another, under a great pressure, for half an hour, the grease being, from time to time renewed, till it had penetrated the pores of the metal, and thus given the rulers a degree of polish which they could not have received by any other means. The friction was at first uncertain, but became more regular as the polish increased.

By this operation the grease penetrates the pores of the metal. The size of the rulers and the touching surfaces were the same as in Art. 5. the velocities of the sledge being imperceptible, or below an inch in a second. The following were the results:

	Pressure.	Friction in parts of the pressure.
Iron upon iron	53 pounds . .	$\frac{1}{6.2}$
	443	$\frac{1}{10.1}$
	1653	$\frac{1}{10.3}$
Iron upon brass	53	$\frac{1}{8}$
	443	$\frac{1}{10.7}$
	1653	$\frac{1}{11}$
Iron upon brass, when the grease was not renewed,	53	$\frac{8}{8}$
	443	$\frac{1}{8.1}$
	1653	$\frac{1}{7.9}$

The ratio between the pressure and the friction depends, in these experiments, on the nature of the unguent and the velocity of the sledge. By greasing the metallic plates with tallow, the friction diminishes greatly under great pressures, in proportion as the velocity augments. In one of these experiments, when the velocity of the sledge was *one foot in a second*, the friction of the sledge, under a pressure of 1652 pounds, was more than one-third less than when the velocity was insensible, or even *one inch in a second*.

When the velocities are insensible, and the pressure is great, the ratio of the pressure and the friction is for

Iron against iron greased with tallow, .	$\frac{1}{10}$
Iron upon brass greased with tallow, .	$\frac{1}{11}$
Iron upon brass greased with tallow, and afterwards with oil, . . .	$\frac{1}{8}$.

When the plates are greased with tallow, this ratio is less under a pressure of 52 lbs. than under one much greater. This arises from the cohesion of the tallow, which opposes under all pressures a constant resistance proportional to the area of the surfaces. This constant resistance, which is not perceptible but under small pressures, may be estimated in the same manner as in Art. 4. p. 673. When olive oil is used, the cohesion may be considered as nothing.

When the surfaces are rubbed with hog's lard, the friction was never less than $\frac{1}{9}$ of the pressure. The resistance depends always on the consistence of the grease, and the friction increases as the grease is more soft.

When the surfaces are greased with tallow, and have a large area, the friction alters the nature of the tallow, and increases sensibly in proportion as the experiments are continued without renewing the grease. It is, however, always less than $\frac{1}{8}$ of the pressure. When the grease is with oil, and the surfaces very small, this effect is less perceptible.

7 *Friction of Iron upon Oak.* When iron moved upon oak, the following were the results:

Pressure.	Time of Contact.	Friction in parts of the pressure.
53 pounds.	½ a second	$\frac{1}{10.6}$
	30 seconds	$\frac{1}{10.1}$
	60 seconds	$\frac{1}{8.1}$
	One hour	$\frac{1}{5.89}$
	Four days	$\frac{1}{5.3}$
1650 pounds.	½ a second	$\frac{1}{13.2}$
	10 seconds	$\frac{1}{12.7}$
	80 seconds	$\frac{1}{11.38}$
	Four hours	$\frac{1}{8.25}$
	Sixteen hours	$\frac{1}{5.9}$
	Four days	$\frac{1}{4.86}$

Hence it appears that in wood rubbing upon metals, the friction does not reach its maximum till after a long time.

When *Brass* rubbed against *Oak*, results analogous to the preceding were obtained. The increase of the friction, however, relative to the time was more slow than in iron; and when it reached its maximum, the ratio was $\frac{1}{5.5}$.

When the velocity was insensible, and the bodies not greased, the following were the results.

	Pressure.	Friction in parts of the Pressure.
Iron upon oak	53 pounds	$\frac{1}{11.8}$
	453	$\frac{1}{12.9}$
	853	$\frac{1}{12.7}$
	1653	$\frac{1}{13.2}$

From these results, it appears that in the first degree of velocity the friction of iron upon oak is nearly $\frac{1}{13}$th of the pressure.

When the sledge had the velocity of one foot per second, the following were the results:

Pressure.	Friction in parts of the pressure.	Pressure.	Friction in parts of the Pressure.
53 pounds	$\frac{1}{5.9}$	853 pounds	$\frac{1}{5.5}$
453	$\frac{1}{5.8}$	1653	$\frac{1}{6.3}$

From which it follows, that the friction has greatly increased with the velocity, that it is nearly constant for the same velocity whatever be the pressure, and that when the frictions increase in an arithmetical progression, the velocities increase in a geometrical progression. Coulomb also found, that under the same pressure, and with the same velocities, the friction is nearly the same for large and small surfaces.

8. *Friction of Iron and Copper on Oak when greased with Tallow.*—When the metals rub upon woods greased with fatty bodies, the friction is greatly diminished, and small velocities are produced with less force than in almost any other species of friction; but when the velocities are increased, the friction augments greatly with the velocity, as in the rubbing of dry metals upon wood. The following were some of the results in very small velocities:

	Pressure.	Friction in parts of the Pressure.
Oak upon iron	1650 pounds	$\frac{1}{35.1}$
Oak upon brass	1650	$\frac{1}{47.1}$

In experiments of this kind, care must be taken to remove the grease, otherwise it acquires consistence, and the resistence sensibly increases. As a proof of this, Coulomb caused the sledge when furnished with plates of brass, to move 15 times over the fixed oaken plank without renewing the tallow. The force of friction was triple that which was employed to give the sledge an insensible velocity when the coat of tallow was new. The velocity of the sledge diminished at every trial, and at the fifteenth it ceased to move. Hence it follows that the tallow is actually injurious, or increases the friction when the surfaces move a long time without the tallow being renewed.

9. *Friction of Iron upon Oak when greased, and when the Surfaces are very small, and the Friction across the Grain of the Wood.*—When the surfaces were covered with tallow, and were afterwards wiped, in order to be merely greasy, the following were the results:

	Pressure.	Friction in parts of the Pressure.
Iron upon oak	47	$\frac{1}{13.4}$
	447	$\frac{1}{14.9}$
	1647	$\frac{1}{11.3}$

These results were nearly the same, whether the surfaces were well tallowed or merely unctuous; and, therefore, it follows, that in this kind of friction, which is analogous to that of axles of iron turning upon wood, the ratio of the pressure to the friction is constant, and is not much influenced by the velocity.

10. *Friction of Oak upon Oak when the Surfaces are in motion.*—In order to examine this kind of friction, Coulomb caused the sledges, when differently loaded, to move over a length of four feet, and having observed the ratio of the times employed to describe successively the two halves of this length, he regarded the force of friction as a constant force during the continuance of the experiment, and the motion of the sledge as uniformly accelerated. He supposes also that the friction is constant, and that it does not vary with the velocity; and upon this hypothesis he finds, that the friction

$$F = A - \frac{2N(A+M)}{gT^2},$$

where g is the force of gravity in 30 feet, A the weight of the loaded scale, M the weight of the loaded sledge, N the number of feet that the sledge describes in T seconds. The masses of the scale A, and the sledge M, are obviously $\frac{A}{g}$ and $\frac{M}{g}$. The moving weight being equal to A—F, the accelerating force must become smaller when this weight is attached to the sledge; and, therefore, if we call it g', we shall have

$$A - F = \left(\frac{A}{g} + \frac{M}{g}\right) g' = (A+M)\frac{g'}{g}$$

But the sledge runs through N feet in T seconds, and $\frac{g'}{2}$ in $1''$; but as the spaces are as the squares of the times, we have

$$T^2 : 1''^2 = N : \frac{g'}{2}, \text{ and therefore } g' = \frac{2N}{T^2},$$

which being substituted for g' in the above equation, gives,

$$F = A - \frac{2N(A+M)}{gT^2}$$

If we therefore determine by experiment the four quantities A, M, N, T, this formula will give, in units of the weight, the value F of the friction, and the ratio of the pressure M to the friction. In every formula, however, we must add to the quantity M a weight of 7 lbs. to represent that part of the resistance which is due to the acceleration of the rotatory motion of the pulley.

When oak rubbed upon oak, in the direction of the fibres, and without any grease, the following results were obtained:

	Pressure in pounds upon a square foot.	Friction in parts of the pressure.
Oak upon oak surfaces one foot square	25 . . .	$\frac{1}{5.7}$
	188 . . .	$\frac{1}{9.4}$
	291 . . .	$\frac{1}{9.5}$
	25 . . .	$\frac{1}{9.4}$
	1788 . . .	$\frac{1}{9.2}$
	6588 . . .	$\frac{1}{10.4}$

When the touching surfaces were reduced to the smallest possible dimensions, so that the sledge rested only in compressed and rounded angles, the results were,

	Pressure	Friction in parts of the pressure.
Oak upon oak surfaces reduced almost to lines.	47	$\frac{1}{10.4}$
	447	$\frac{1}{12.4}$
	847	$\frac{1}{14.6}$

When the velocities in both these sets of experiments were varied from nothing to four feet in four or five seconds, the friction was not perceptibly altered.

When the surfaces were very large compared with the pressures, the friction *appeared to augment with the velocities*; but when the touching surfaces were very small, compared with the pressures, the *friction diminished, or the velocities increased*. In the first experiment of the first of the above results, the friction became greater than $\frac{1}{5.7}$ when the velocity was increased. Here the varieties are ascribed by Coulomb to some cause foreign to friction, and depending on the extent of the surfaces; and he seems to think that the surfaces may be covered with a sort of down, which must be bent during the motion of the surfaces. The resistance produced by this down is independent of the cavities and solid parts which enter into one another, and which occasion a friction proportional to the extent of the surface. If this is the cause which alters the law of friction under small pressures, the friction ought also to be augmented with the velocity, since, under a great velocity, a greater number of the parts which form the down are bent, and this is actually what was found by experiment.

General Results.—From the preceding experiments M. Coulomb has drawn the following general conclusions:

1. The friction of wood upon wood, when ungreased, occasions, after a sufficient period of contact, a resistance proportional to the pressure. This resistance increases sensibly in the first instants of repose, but after some minutes it generally reaches its maximum.

2. When wood, ungreased, moves upon wood, with any velocity whatever, the friction is still proportional to the pressure, but its intensity is much less than that which is experienced in detaching the surfaces after some minutes of rest. The force, for example, which is necessary to detach two surfaces of oak after some minutes of rest, is to that necessary for overcoming the friction when the surfaces have already any degree of velocity whatever, nearly as 9.5 to 2.2.

3. The friction of metals sliding over metals, ungreased, is also proportional to the pressures, but its intensity is the same, whether the surfaces detached have been any time at rest, or whether they have received any uniform velocity whatever.

4. Heterogeneous substances, such as those of woods and metals, sliding upon one another without grease, give for their friction very different results from the preceding; for the intensity of their friction relative to the time in which they have continued in contact increases slowly, and does not reach its maximum till after four or five days, and sometimes more, whereas in the metals it reaches its maximum in an instant, and in wood, after a few minutes. This increase is even so slow that the resistance of friction in insensible velocities is nearly the same as that which takes place in moving or detaching the surfaces after three or four seconds of rest. In the motion of wood rubbing upon wood without grease, and in metals moving upon metals, the velocity has very little influence upon the friction, but in the present case the friction increases very sensibly in proportion as we increase the velocities; so that the friction increases nearly in arithmetical progression as the velocities increase in geometrical progression.

Coulomb supposes, that the fibres of wood are as shown in Plate CCCLXVII. Fig. 10. which represents one surface lying upon another. Fig. 11. represents them when bent, after a force is applied to the upper surface, but before the fibres are detached from one another. Fig. 12. represents them when they are detached, and the upper body is in motion over the under one. Fig. 13. represents the surfaces of metals.

SECT. II. *On the Friction of Axles.*

THE principal object of Coulomb, in his experiments on this subject, was to determine the friction of the axles of machines in motion. He employed axes of iron moving in boxes of brass. The iron axis was 19 lines in diameter, and had a play of 1⅔ lines in the brass box. The pulley in which the axis was fixed was 144 lines in diameter, and its weight 14 lbs. Previous to the experiments, the iron axis was made to work in the brass box till the touching surfaces acquired the highest polish of which they were susceptible. M. Coulomb caused the suspended weights to run through a space of 6 feet, and he measured separately in half seconds the time employed to run through the first three feet, and the time occupied in running through the last three feet. In this way he obtained the results in the following table, arranged by M. Prony:

TABLE of Coulomb's Experiments on the Friction of Axles.

Number of Experiments.	Kind of Cord used.	Kind of Greasing	Weight used to end the Cord over the Pulley	Weight hung on each side of the Pulley.	Additional weight to move the Pulley.	Motion of the weight suspended on each side of the Pulley.	Pressure on the Axis.	Friction reduced to Surface of Axis.	Ratio of Friction to the Pressure.
1	Very flexible thread of three lines circumference.	Friction without greasing.	0.0	103	6	Slow and irregular.	226	42	0.186
2	Cord No. 1. of 6 threads in a yarn.	Idem.	1.5	200	10.5 13.5	Slow and irregular. The first 3 feet fallen through in 6″, the last 3 in 3″.	424	65	0.153
3	Idem.	Idem.	3.0	400	21 28 39	Slow but continual. The first 3 feet described in 5″.5, the last 3 in 2″.5. First 3 feet described in 3″, the last 3 in 1½‴.	825	13	0.156
4	Very flexible thread of two lines circumference.	Tallow.	0.0	100	2.5 6	Slow but continual. The first 3 feet described in 3″.5, the last 3 in 1″.5.	216.5	17.5	0.081
5	Cord No. 1. of six threads in a yarn.	Idem.	1.5	200	6.5 10 0	Slow but continual. The first 3 feet described in 3″.5, the last 3 in 1″.5.	420	36	0 086
6	Idem.	Idem.	3.0	400	13 18 24	Slow and continual. The first 3 feet described in 5″.5, the last 3 in 2″. First 3 feet in 3″, last 3 in 2″.	827	72	0.087
7	Thread of two lines in circumference.	Cart grease.	0 0	50	2.5	Slow and continual.	117	17.5	0.15
8	Idem.	Idem.	0.0	100	3.7	Idem.	218	26	0.119
9	Idem.	Idem.	0.0	150	5.7	Idem.	230	40	0.125
10	Cord No. 1. of six threads in a yarn.	Idem.	0.7	100	4.3 9	Slow and uncertain. First 3 feet in 3″, last 3 in 1½″	218	26	0.119
11	Idem.	Idem.	1.5	200	8.5 14 20	Uncertain. First 3 feet in 4″, last 3 feet in 2″. All 6 feet in 3″.5.	422	50	0.118
12	Idem.	Idem.	3.0	400	17 22 28	Uncertain. First 3 feet in 6″.5, last 5 feet in 2″.5. First 3 feet in 4″, last 3 feet in 1″.5.	831	101	0 121
13	. . . . . .	The cart grease of preceding experiment wiped. the pores of the metal remained unctuous.	. .	. . .	. . .	. . . .	From 200 to 1200 lbs.	. .	0.127
14	. . . . . .	The surface fresh done with oil.	. .	. . .	. . .	. . . .	. . .	. .	0.127 0.133
14	. . . . . .	The greasing not renewed for a long time, though the machine had been much used.	. .	. . .	. . .	. . . .	. . .	. . .	0 133

The weights in col. 4. which were employed to bend the cord, were computed from the numbers in col. 5. by means of the formulæ given in Sect. IV. and the results of some previous experiments. The weights in col. 4. being subtracted from those in col. 6. which put the pulleys in motion, give the weights actually employed in overcoming the friction. As these last weights acted at the end of a lever equal to the radius of the pulley, *plus* the radius of the cord, the friction upon the axis may be regarded as equal to the product of these weights into the ratio of the sum of the radii of the pulley and the cord to the radius of the axis, which is nearly that of 7 to 1, when the weight is suspended by a thin pack-thread, and nearly 7.2 to 1, when it is suspended by the cord No. 1. By this method the friction in col. 9. was calculated. The pressures on the axis in col. 8. are obviously composed, 1st, Of the weight of the pulley or cylinder; 2d, of double the corresponding weight in col. 5.; and 3d, of the weights contained in col. 6. The ratio therefore of the friction to the pressure in col. 10. is the quotient arising from dividing col. 9. by col. 8.

It appears from experiments 7th, 8th, 9th, 10th, 11th, and 12th columns, that the friction of axes of iron in boxes, or cheeks of brass, is much less diminished by the cart grease than by tallow.

M. Coulomb likewise extended his experiments to the friction of axles made of the different kinds of wood used in rotatory machines. He used pulleys of 12 inches in diameter, with axes three inches in diameter. The axes were sometimes moveable, and at other times fixed, though in both cases the friction was the same. The levelling surfaces were carefully smoothed.

Names of the Wood used for the Axles.	Ratio of Friction to pressure.	
1. Axis of *Holm Oak* running in a box of lignum vitæ coated with tallow, . . .	0.038	$\frac{1}{26.3}$
2. Do. the coating of tallow wiped off, and the surface remaining greasy, ...	0.06	$\frac{1}{16.7}$
3. Do. after being used several times without renewing the tallow.	0.06 0.08	$\frac{1}{16.7}$ $\frac{1}{12.5}$
4. Do. running in a box of *Elm* coated with tallow, . .	0.03	$\frac{1}{33.3}$
5. Do. both axis and box wiped, and the surfaces remaining greasy, ...	0.05	$\frac{1}{20}$
6. Axis of *Boxwood*, and box of *Lignum Vitæ*, coated with tallow, ...	0.043	$\frac{1}{23}$
7. Do. the coating wiped, and the surfaces remaining greasy,	0.07	$\frac{1}{14.3}$
8. Axis of *Boxwood*, and box of *Elm*, coated with tallow, .	0.035	$\frac{1}{28.6}$
9. Do. the coating wiped off, and the surfaces remaining greasy,	0.05	$\frac{1}{20}$
10. Axis of *Iron*, and box of *Lignum Vitæ*, the coating wiped off, and the pulley turned for some time, . . .	0.05	$\frac{1}{20}$

In these experiments the velocity did not appear to influence the friction unless in the first instants of rest, and in all cases the friction was least when the surfaces were merely greasy, and not coated with tallow.

Sect. III. *On the Friction and Rigidity of Ropes.*

When a rope passes over a cylinder, or over the groove of a pulley whose axis is horizontal, and has a weight suspended at each end of it, then it is obvious, that if the rope were destitute of rigidity, or perfectly flexible, the axis of the ropes on each side would be perfectly parallel and vertical. But as every rope is stiff or rigid, the two branches of it that suspend the weights will deviate from the perpendicular. If one of the ends of the rope is fixed in such a manner that the first branch of the rope is in a vertical direction, and if we suspend, at the other end of the rope, a weight W, which will stretch the second branch of the rope to such a degree as to force it into a vertical direction, and to bring it in contact with a semicircumference of the pulley, the weight W *may be taken as the measure of the rigidity of the rope.*

If the rope, instead of being treated in this manner, has two equal weights, W, W, suspended at each extremity, and if we add to one of the ends an additional weight w, capable of destroying the equilibrium of the equal weights, W, W, this weight may be taken as a measure of the friction of the rope. A small portion indeed of the weight w is employed in overcoming the rigidity of the rope; but it is so small, when compared with w, that it may be safely neglected.

The first experiments that appear to have been made on the rigidity of ropes, were those of Amontons, who contrived an ingenious apparatus for this purpose. He has published, in the *Memoirs of the Academy of Sciences* for 1699, a table of the forces required to bend ropes, founded on the supposition that the difficulty of bending a rope of the same thickness, and loaded with the same weight, "decreases when the diameter of the roller or pulley increases, but not so much as that diameter increases."

Another series of experiments was afterwards made by Desaguliers, (See *Course of Natural Philosophy*, vol. I. p. 243, 244, 245, &c.) who published a table, "showing what forces were required to bend ropes of different diameters, stretched by different weights round rollers of different bignesses." The general result of these experiments was, *that the difficulty of bending a rope round a roller is, cæteris paribus*, inversely as the diameter of the roller.

The experiments on the rigidity and friction of ropes made by Coulomb were performed, both with the apparatus used by Amontons, and by another of his own, which is shewn in Plate CCCLXVII. fig. 14. It consists of two tressels 6 feet high, on which are laid two pieces of square wood, *ab*, *cd*. On these two pieces are fixed two rulers of oak, DD, D′D′, well planed, and polished with fish-skins. With two cylinders of *lignum vitæ*, one 6 inches in diameter, and the other 2 inches; and, with several cylinders of elm, from 2 to 12 inches in diameter, the apparatus was ready for the experiments.

In order to ascertain the friction of the rollers, they were laid on the planks, as shown in Fig. 14. and a weight of 50lbs was suspended on each side of the roller, with very fine and flexible pack-thread; and the weights could be increased in any degree by laying additional weights of 50 lbs. by different threads, so as to give any required pressure to the rollers. By adding a counterweight on each side of the roller alternately, till they received a motion barely sensible, Coulomb ascertained the friction of the rollers. The following were the results with rollers of lignum vitæ :

Pressure upon the Rollers.	Weights which produced an extremely slow motion. Roller of 6 in. Diam.	Roller of 2 in. Diam.
100	0.6 lb.	1.6
500	3 0	9.4
1000	6.0	18.0

Hence it follows, *that the friction of cylinders rolling upon horizontal planes, are directly as the pressures, and inversely as the diameter of the rollers.*

Coulomb found that greasing the ropes did not diminish the friction sensibly. He found also, that rollers of elm had a friction about two-fifths greater than lignum vitæ; and that under small pressures the friction was rather greater than would result from its being proportional to the pressure.

The rigidity of ropes was measured in the way already described, and the following results were obtained. The rollers varied from 2 to 12 inches in diameter, and the pulley ropes were used.

	Threads in a Yarn.	Threads in a Strand.	Circumference.	Weight of a Foot.
No. 1.	6	2	$12\frac{1}{2}$ lines.	$4\frac{1}{2}$ drs
No. 2.	15	5	20	$12\frac{1}{2}$
No. 3.	30	10	28	$24\frac{1}{2}$

TABLE of Coulomb's Experiments on the Rigidity and Friction of Ropes.

No. of Experiments.	Cords used in the experiments.	Kinds of wood, diameter, and weight of the rollers.	Weights hung on each side of the roller in lbs.	Additional weight to overcome friction of roller, and stiffness of cords.	Total load upon the rullers which support the rollers.	Friction of the roller.	Stiffness of the Cord. As ascertained by Coulomb's apparatus.	Stiffness of the Cord. As ascertained by Amonton's apparatus.
1	Cord No. 3. of 30 threads in a yard.	*Elm* 12 inches diameter, weight 110 lbs.	100	5 lbs.	315	1.5	3.5	4.4
			300	11	721	3.6	7.4	10.4
			500	20	1130	5.6	14.4	16.4
2	Idem.	*Elm* 6 inches diameter, weight 25 lbs.	200	18	443			
3	Idem.	*Guiacum* 6 inches diameter, weight 50 lbs.	200	16	466	2.8	13.2	14.8
4	Idem.	*Guiacum* 2 inches diameter, weight $4\frac{1}{2}$ lbs.	25	11	$65\frac{1}{2}$			
			200	52	$456\frac{1}{2}$			
5	Cord No. 2. of 15 threads in a yarn.	*Guiacum* 6 inches diameter, weight 50 lbs.	25	$1\frac{1}{4}$	$101\frac{1}{4}$			
			100	6	256			
			200	11	461	2.8	8.2	7.6
			500	24	1074	6.4	17.6	17.8
6	Cord No. 1. of 6 threads in yarn.	Idem.	100	3	253	2.7	3.3	3.1
			200	6	456			

As the preceding experiments were made in the case of motions nearly insensible, Coulomb proceeded to ascertain the effect produced by the rigidity of the cords as changed by the velocity. With this view, he took a pulley, and a box of copper, and an axis of iron, coated with tallow. The pulley was 144 lines in diameter, and the axis $20\frac{1}{2}$ lines, and the cord was No 3. the same as that used in the above experiment. The weights were made to run above a distance of 6 feet, and the times of describing the first three and the last three feet were measured by a half-second pendulum.

No. of Experiments.	Weight hung on each side the pulley.	Additional weight to move the pulley.	Part of weight to overcome friction and rigidity.	Motion of the weights hung upon the pulley.	Pressure on the axis in lbs.	Weight acting at extremity of pulley, balancing the friction.	Stiffness of the cord deduced from the weights which move the pulley.	Stiffness of the cord, estimated from its tension, and former experiments.
1.	100lbs.	7.5 lbs.	7.5 lbs.	Slow and continued	221	2.6 lbs.	4.9 lbs.	4.0 lbs.
		12	7.6	First 3 feet in 3′ Last 3 feet in 1½″				
		15	7.6	First 3 feet in 2″ Last 3 feet in 1½″				
2.	200	11	11	Slow and uncertain	425	4.9	6.1	6.6
		15	12.9	First 3 feet in 6″ Last 3 feet in 3″				
		19	12.2	First 3 feet in 3½″ Last 3 feet in 1½″				
3.	400	20.5	20.5	Slow and uncertain	834	9.7	10.8	11.8
		24	19.9	First three feet in 6″ Last 3 feet in 3″				
		31	17.6	First 3 feet in 3″ Last 3 feet in 2″				
4.	600	31.5	31.5	Doubtful and continued	1235	14.5	17.0	17.0
		37	31.5	First 3 feet in 6″ Last 3 feet in 3½″				

The following are the general results of Coulomb's experiments:

1. The rigidity of ropes increases, the more that the fibres of which they are composed are twisted.

2. The rigidity of ropes increases in the duplicate ratio of their diameters. According to Amontons and Desaguliers, the rigidity increases in the simple ratio of the diameters of the ropes; but this probably arose from the flexibility of the ropes which they employed.

3. The rigidity of ropes is in the simple and direct ratio of their tension.

4. The rigidity of ropes is in the inverse ratio of the diameters of the cylinders round which they are coiled. This result was obtained also by Desaguliers.

5. In general, the rigidity of ropes is directly as their tensions and the squares of their diameters, and inversely as the diameters of the cylinders round which they are coiled.

6. The rigidity of ropes increases so little with the velocity of the machine, that it need not be taken into the account when computing the effects of machines.

7. The rigidity of small ropes is diminished when penetrated with moisture; but when the ropes are thick, their rigidity is increased.

8. The rigidity of ropes is increased, and their strength diminished, when they are covered with pitch; but when ropes of this kind are alternately immersed in the sea and exposed to the air, they last longer than when they are not pitched. This increase of rigidity, however, is not so perceptible in small ropes as in those which are pretty thick.

9. The rigidity of ropes covered with pitch is a sixth part greater during frost than in the middle of summer, but this increase of rigidity does not follow the ratio of their tensions.

10. The resistance to be overcome in bending a rope over a pulley or cylinder may be represented by a formula composed of two terms. The first term $\frac{aD^n}{r}$ is a constant quantity independent of the tension, a being a constant quantity determined by experiment, D^n a power of the diameter D of the rope, and r the radius of the pulley or cylinder round which the rope is coiled. The second term of the formula is $T \times \frac{b\,D^n}{r}$, where T is the tension of the rope, b a constant quantity, and Dn and r the same as before. Hence the complete formula is $\frac{aD^n}{r} + T \times \frac{bD^n}{r} = \frac{D^n}{r} \times a + T\,b$. The exponent n of the quantity D diminishes with the flexibility of the rope, but is generally equal to 1.7 or 1.8; or, as in No. 2. the rigidity is nearly in the duplicate ratio of the diameter of the rope. When the cord is much used, its flexibility is increased, and n becomes equal to 1 5 or 1.4.

SECT. IV —*On the Friction and Form of Pivots.*

In the ninth volume of the *Mémoires des Sçavans Etrangers*, p. 234, M. Coulomb has given the theory of the friction of pivots and the cups which they support; but as the experiments on which it was founded were neither sufficiently numerous, nor made with sufficient accuracy, he afterwards resumed the subject, and has published the results of his observations in the Memoirs of the French Academy for 1798, under the title of *Sur les Frottemens de la pointe des Pivots*.

The needles of compasses are generally suspended upon a pivot, by means of caps of agate, or other hard substances. The cap has a conical form, terminated above with a small concave summit, whose radius of curvature is very small. The pivots themselves are generally of tempered steel, but frequently reduced to the state of a spring. The point of the pivot which supports the cap is a small curve surface, whose radius of curvature is smaller than that of the summit of the cap. Coulomb generally found, that even when every care was taken by the artist, the curvature of the summit of the cap was very irregular, and that the friction of an agate cap, turning upon the point of a pivot, was often five or six times greater than the momentum of friction of a highly polished agate plane turning on the same pivot.

Coulomb, in his experiments on pivots, supported the body by a highly polished plane in place of a cap, and having given it a rotatory motion, he noted, by means of a seconds watch, the time employed in making the *four* or *five* first turns, from a mean of which he obtained the primitive velocity; and he next counted the number of turns which it made before it stopped. The revolving body is obviously brought to rest by the friction of the point of the pivot, and also by the resistance of the air; but in order to get rid of this last resistance, Coulomb gave the body the form of a glass receiver, and found, that when the velocity was not great, and when the receiver weighed 5 or 6 gros (a gros is the eighth of an ounce) the resistance of the air bore no sensible ratio to that of the friction.

In order to render the results more certain, he made several of the experiments in vacuo by the apparatus shown in Plate CCCLXVII. Fig. 15. where *a k h b* is a fork formed of brass wire, attached to a plane surface at *d*, or, what is better, to a concave lens of glass, whose radius of curvature is from two to three lines. To the extremities of the fork are fixed two plates of metal, *a b*. A motion of rotation is communicated to the fork by means of a moveable rod *e f k*, formed into a hook at *f*, and which is introduced into the neck of the receiver AB, in which the vacuum is made. When the distance *a b* is 2 inches, when the fork performs its first revolution in 7 or 8 seconds, and when the weight of *a* and *b* is about 5 or 6 gros, it is unnecessary to perform the experiments in vacuo. The apparatus, however, should be protected from currents of air by being placed under a receiver.

With the first apparatus, consisting of a glass receiver 4 inches in diameter, 5 inches high, and weighing 5 ounces, Coulomb got the following results:—

	Time of making one revolution, in seconds.	Number of revolutions before it stopped.	Values of $\frac{b^2}{X}$
Experiment 1.	4″	$34\frac{1}{10}$ turns.	$\frac{1}{547}$
Experiment 2.	$6\frac{1}{4}$	$14\frac{1}{10}$	$\frac{1}{550}$
Experiment 3.	11	$4\frac{6}{10}$	$\frac{1}{557}$

The numbers in the last column were calculated by means of the formula

$$A=\frac{b^2}{X}\times\int\frac{\mu r^2}{a}\text{*}$$

where A is the momentum of friction, b the primitive velocity, X the space described from the beginning to the end of the motion, $\int\frac{\mu r^2}{a}$ the sum of the products of each molecule μ, by the square of its distance r from the axis of rotation, divided by the quantity a, or the distance from the axis of rotation of a point whose velocity is b.

Now, as the same receiver was employed in the above three experiments, the term $\int\frac{\mu r^2}{a}$ is constant, and therefore, if the other term $\frac{b^2}{X}$ is constant, A will be constant. Hence it follows, that since the experimental values of $\frac{b^2}{X}$, as given in the last col. are nearly the same, we may conclude, *that the friction of pivots is independent of the velocity*, and is therefore necessarily proportional to some function of the pressure.

In order to examine the friction of pivots, when they support planes of different materials, M. Coulomb made the fork *a k h b* nine inches long. The parallel branches *a k*, *h b* were 24 lines distant from each other. The curve *k d h* was a semicircle, and about three inches long; and the length of the two parallel branches was also three inches each. The pieces of metal *a*, *b*, and the plane *d*, were fastened to the wire by wax. At *g*, the summit of the support, was fixed a small needle *g d* of tempered steel, the point of which could be made more or less fine, round, or obtuse, according to the nature of the caps, and the magnitude of the pressure. In the following experiments, the angle of its summit was about 18 or 20 degrees. The weight of *a* and *b* was two gros each, and that of the fork $1\frac{1}{3}$ gros.

	Time of making one revolution.	Number of revolutions before it stopped.	Values of $\frac{b^2}{X}$	Friction.
Garnet plane at *d* highly polished.	12″ 23	7 2	$\frac{1}{1008}$ $\frac{1}{1050}$	1.000
Agate plane highly polished.	9 15	$10\frac{1}{2}$ $3\frac{1}{2}$	$\frac{1}{851}$ $\frac{1}{844}$	1.214
Rock Chrystal plane highly polished.	13 $14\frac{1}{2}$	$4\frac{5}{8}$ $3\frac{3}{4}$	$\frac{1}{781}$ $\frac{1}{787}$	1.313
Glass plane highly polished.	$8\frac{3}{4}$ $4\frac{3}{4}$	$7\frac{1}{2}$ $2\frac{9}{10}$	$\frac{1}{570}$ $\frac{1}{589}$	1.777
Steel plane tempered and polished.	17 8	$1\frac{3}{4}$ $7\frac{1}{4}$	$\frac{1}{510}$ $\frac{1}{464}$	2.257

Hence it follows, that garnet is far superior to the other substances for the caps of pivots.

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* The investigation of this formula will be found in the *Mem. Acad. Par.* 1790, p. 451, 452.

In order to ascertain the effect produced by giving different forms to the pivot of the needle, Coulomb made the following experiments, the circumstances being the same as in the preceding experiments.

Nature of the planes.	Values of $\frac{b^2}{X}$ Angle of pivot 45°	Values of $\frac{b^2}{X}$ Angle of pivot 6° or 7°.
Garnet,	$\frac{1}{2500}$	
Agate,	$\frac{1}{2100}$	$\frac{1}{800}$
Glass,	$\frac{1}{1400}$	$\frac{1}{450}$
Steel,	$\frac{1}{2000}$	$\frac{1}{230}$

Hence, for a plane of agate, we have

For a pivot of 45°	$\frac{b^2}{X} = \frac{1}{2100}$
15°	$\frac{1}{1200}$
6°	$\frac{1}{800}$

From these experiments, it appears that in *garnet*, *agate*, and *glass*, under a pressure of $5\frac{1}{3}$ gros, the friction *increases as the pivots become more acute*, and follows nearly the same ratio. The case, however, is different with steel. In agate and steel, the frictions upon a pivot of 45° are nearly equal, being $\frac{1}{2100}$ for agate, and $\frac{1}{2000}$ for steel; whereas, on a pivot of 6° or 7°, the friction for agate is $\frac{1}{800}$, and $\frac{1}{230}$ for steel. Coulomb ascribes this difference to the irregular contexture of metals, and particularly steel, which he says is covered with an infinity of small holes, even when it has the finest polish. He conceives, therefore, that the increase of friction in the steel arises from the sharp point of the pivot working in these irregular openings.

When the weight of the needle, or body supported on the pivot, is under 100 grains, very little advantage is gained by giving the pivots a greater angle than 18° or 20° degrees. When the needles are very light, the angle of the pivot should be less than 18°.

As the preceding results are not applicable to all degrees of pressure, Coulomb repeated the experiments by varying the weights *a* and *b*. He used also a small plane *d*, of highly polished glass, and then a plane of garnet, and made the angle of the pivot about 45°. The fork always weighed $1\frac{1}{3}$ gros. The distance *a b* was 24 lines.

Load upon the pivot in gros.	Time of performing one revolution.	Number of revolutions before it stopped.	Values of $\frac{b^2}{X}$
With a Plane of Polished Glass.			
5.33	24	2	$\frac{1}{1152}$
	14	$5\frac{3}{4}$	$\frac{1}{1127}$
	10	$11\frac{3}{4}$	$\frac{1}{1175}$
16.66	9	$10\frac{1}{4}$	$\frac{1}{830}$
	13	$4\frac{1}{4}$	$\frac{1}{802}$
With a Plane of Garnet.			
5.33	—	—	1/2[illegible]
16 66	—	—	$\frac{1}{1550}$

It is a remarkable circumstance, that Coulomb found the results much more regular with glass than either with garnet or agate. Hence, as the friction was likewise greater, he preferred it for the preceding experiments.

From these experiments, Coulomb has shewn, that the exponent of the power of the pressure to which the friction is proportional, is 1 33, or $\frac{4}{3}$.

The following is a recapitulation of Coulomb's results.

1st, The friction of pivots is independent of the velocities, and is a function of the pressure.

2d, The friction of garnet is less than that of agate, and that of agate less than that of glass; but the friction of different parts of a plane of polished glass is less irregular.

3d, The angles of the points of pivots has an influence on the friction. When the body weighs five or six gros, the best angle is from 30 to 45 degrees. When the body weighs less, the angle of the pivot may be progressively diminished without the friction experiencing any sensible increase. We may even, without much inconvenience, and when the steel is good, reduce it to 10 and 12 degrees, provided the weight of the body does not exceed a hundred grains.

4th, With a pivot of the best steel, well tempered, and brought to the first degree of steel temper, and having an angle of 45 degrees, the momentum of friction varies as the $\frac{4}{3}$d power of the pressure. When the pressure was very considerable, and the pivot shaped to any angle, the friction varied nearly as the pressure.

5th, All the caps which Coulomb procured from the best workmen appeared to be very irregular in their concavity. The momentum of their friction, under pressures of even more than five or six grains, is always much more considerable, and sometimes triple and quadruple of that of a well-polished plane of the same substance; and in order to support these caps, it is necessary that the points of the pivots be shaped to an angle less than that which is necessary to support planes.

SECT. V. *On the Methods of diminishing Friction in Machinery.*

The experiments which have been detailed in the preceding sections will furnish the practical mechanic with various rules respecting the nature and form of the materials which should form the supports and the communicating parts of machines, respecting the nature of the unguents which should be applied to them, and the mode of their application.

The most efficacious contrivances for diminishing friction, are *friction-wheels*, by means of which, that species of friction which arises from one body being dragged over another, is changed into that which arises from one body rolling upon another. The application of friction-wheels is shown in the drawing of Atwood's machine, (Plate CCCLXVIII. Fig. 1.) and in another form in Figs. 16 and 17. of Plate CCCLXVII. Fig. 16. represents M. Gottlieb's anti-attrition axle-tree, which consists of a steel roller R, about five inches long, turning in a groove cut in the lower part of the axle-tree C, which works on the nave AB. Fig. 17. shows the method of applying friction-rollers used by Mr. Gamett. A space between the axle E, and the nave of the wheel ABDC, is filled with friction-rollers, R, R, R, &c. whose axes are inserted in circles of brass, which are rivetted together by means of bolts which pass between the rollers, in order to keep them separate and parallel. When the moving force is not exerted in a perpendicular direction, but obliquely, as in undershot wheels, the gudgeon will press with greater force on one part of the socket than on any other part. This point will evidently be on the side of the bush opposite to that where the power is applied; and its distance from the lowest point of the socket, which is supposed circular and concentric with the gudgeon, being called x, we shall have Tang. $x=\frac{H}{V}$, that is, the tangent of the arch contained between the point of greatest pressure and the lowest point of the bush, is equal to the sum of all the horizontal forces, divided by the sum of all the vertical forces and the weight of the wheel, H representing the former, and V the latter quantities. The point of greatest pressure being thus determined, the gudgeon must be supported at that part by the largest friction-wheel, in order to equalize the friction upon their axles.

Friction-wheels seem to have been first recommended by Casatus. They were afterwards mentioned by Sturmius and Wolfius, but were not in actual use till Sully applied them to clocks in 1716, and Mondran to cranes in 1725. They remained, however, almost unnoticed till the celebrated Euler explained their nature and advantages in his memoirs *on Friction*, referred to at the end of this chapter.

Another method of diminishing friction is to apply the impelling power (when it can be done) in such a way as to act either in opposition to, or obliquely to the force of gravity.

If we suppose, for example, that the weight of a wheel, whose iron gudgeons move in bushes of brass, is 100 pounds, then the friction arising from both its gudgeons will be equivalent to 25 pounds. If we suppose also that a force equal to 40 pounds is employed to impel the wheel, and acts in the direction of gravity, as in the cases of overshot wheels, the pressure of the gudgeons upon their supports will then be 140 pounds, and the friction 35 pounds. But if the force of 40 pounds could be applied in such a manner as to act in direct opposition to the wheel's weight, the pressure of the gudgeons upon their supports would be 100 — 40, or 60 pounds, and the friction only 15 pounds. It is impossible indeed to make the moving force act in direct opposition to the gravity of the wheel, in the case of water-mills; and it is often impractible for the engineer to apply the impelling power but in a given way: but there are many cases in which the moving force may be so exerted, as at least not to increase the friction which arises from the wheel's weight. Appendix to *Ferguson's Lectures*, vol ii.

A contrivance for diminishing friction, by rendering an axis of rotation unnecessary, is shown in Plate CCCLXVII. Fig. 18. where A is a cylindrical wheel, without an axis of rotation, but turned by the rope $r\,r$, passing round a groove in its circumference. The wheel A is supported by the three wheels or rollers, w, w, w, which have a groove hollowed out upon their circumference.

Another method of diminishing friction, proposed by M. Gaston de Thiville, is shown in Plate CCCLXVII. Fig. 19. The wheel R has two hollow cylinders, m, n, fixed to its axle AB. These cylinders are made to float in boxes filled with water, in such a manner that the gudgeons pass through the boxes of water, so as to be water tight without preventing their rotation. The weight of the wheel is thus supported upon the floating cylinders, and it is kept in its place by the gudgeons x, y.

The friction of the axis of particular machines may be diminished by counter-weights placed in the manner represented in Plate XLVII. Fig. 1. and described under the article Astronomy.

As it appears from the experiments of Coulomb, that the least friction is generated when polished iron moves upon brass, the gudgeons and pivots of wheels, and the axles of friction rollers, should all be made of polished iron; and the bushes in which these gudgeons move, and the friction-wheels, should be formed of polished brass. In small and delicate machinery, the cups, or planes, which support pivots, or upon which knife-edges rest, as in balances and pendulums, should be made of garnet in preference to any other substance.

When every mechanical contrivance has been adopted for diminishing the obstruction which arises from the attrition of the communicating parts, it may be still farther removed by the judicious application of unguents. The most proper for this purpose are swine's grease and tallow, when the surfaces are made of wood, and oil, when they are of metal. When the force with which the surfaces are pressed together is very great, tallow will diminish the friction more than swine's grease. When the wooden surfaces are very small, unguents will lessen their friction a little, but it will be greatly diminished if wood moves upon metal greased with tallow. If the velocities, however, are increased, or the unguent not often enough renewed, in both these cases, but particularly in the last, the unguent will be more injurious than useful. The best mode of applying it is, to cover the rubbing surfaces with as thin a stratum as possible, for the friction will then be a constant quantity, and will not be increased by an augmentation of velocity.

In small works of wood, the interposition of the powder of black lead has been found very useful in relieving the motion. The ropes of pulleys should be rubbed with tallow, and whenever the screw is used, the square threads should be preferred." *See Appendix to Ferguson's Lectures*, vol. ii.

In order to apply unguents to the communicating parts of machines, various contrivances have been adopted. The spindles of trundles have been made hollow, to contain oil, so that when they had a horizontal position, they allowed it to drop from small apertures upon the wheel below, by which they were driven.

Mr. Brown's method of applying oil to the axle tree of a carriage, will be found under the article COACHMAKING, and some valuable remarks on the friction and oiling of jewelled holes will be found in our article HOROLOGY.

For farther information on the subject of friction, See Amontons *Mem. Acad.* Par. 1699, p. 206; Belidor, *Architect. Hydraulique*, vol. i. chap. ii. p. 70; Bulfinger, *Comment Petrcpol.* tom. ii. p. 40; Parent, *Recherches de Mathematique et Physique*, 1713, tom. ii. p. 462, and *Mem. Acad.* Par. 1704, p. 174; De la Hire, *Mem. Acad. Par.* tom. ix. p. 119.; Hermand, *Machines Approuvées*, tom. iii. 7; Mondran, *Mem. Acad. Par. Hist.* p. [illegible], and *Mach. Approuv.* iv. 119; Fitzgerald, *Phil. Trans.* 1763, p. 139; Camus's *Traité des Forces Mouvantes*, chap. iv. sect. iv. p. 300, 332, Paris, 1732; Desaguliers's *Course of Experimental Philosophy*, vol. i. p. 190; Euler, *Sur le Frottement des Corps solides*, Mem. Acad. Berlin, 1748, p. 122, and *Sur le diminution de la resistance du frottement*. Mem. Acad. Berl. 1748, p. 133; Nollet, *Leçons de Physique*, tom. iii. p. 251, edit. 1770; Bossut's *Traité Elémentaire de Mécanique*, part i. chap. iv. sect. iv. p. 178, edit. 1802; Vince, *Philosophical Transactions*, vol. 75, p. 167; Coulomb, *Mémoires des Scavans Etrangers*, tom. ix. and x; Coulomb, *Mem. Acad. Par.* 1790, p. 448; *Journal de Physique*; Van Swinden's *Positiones Physicæ*; Ferguson's *Lectures on Machines*, &c. tom. ii; Prony's *Architecture Hydraulique*; Poisson's *Traité de Mecanique*, tom. i. p. 174; Hachette's *Traité des Machines*, p. 255.

PART III. DESCRIPTION OF MACHINES.

It cannot be expected, in a work like this, that we should even attempt to give a general outline of the various machines which have either been employed, or which are at present in use in our numerous manufactures, or in the great public works which are at present carrying on throughout the kingdom. We have already devoted many of our pages to the description and representation of various important machines, which are distinguished by their superior ingenuity or utility; and in order to complete the full view which we proposed to give of the principal manufactures and mechanical operations by which this country has attained such a high distinction among foreign nations, we shall continue the subject in the succeeding volumes of our work. In the present article, we shall limit ourselves to two classes of machines, namely,

I. Those which are illustrative of the doctrines of Dynamics and Mechanics; and

II. Those which are of such a general nature, that they may be applied to various purposes, or which could not be referred to any general subject.

We shall then conclude this article with a general arrangement of machines, and a reference to all those which have been described in various parts of the present work.

CHAP. I.

DESCRIPTION OF MACHINES ILLUSTRATIVE OF THE DOCTRINES OF DYNAMICS AND MECHANICS.

SECT. I. *Description of Atwood's Machine.*

This ingenious machine, which we have represented in Plate CCCLXVIII. Figs. 1. and 2. was invented by Mr. Atwood, for the purpose of illustrating the doctrines of accelerated and retarded motion; and by means of it we are enabled to ascertain experimentally, 1. The quantity of matter moved; 2. The moving force; 3. The space described; 4. The time in which the space is described; and 5. The velocity acquired at the end of that time.

This machine consists of a fixed brass pulley or wheel *a b c d*, moving upon a horizontal axis of steel. Each extremity of this axis rests upon two friction-wheels, whose axes are horizontal, and the whole is placed upon a platform CD, placed at the top of a vertical pillar CQ, whose base can be put into a true horizontal position by the screws *s*, *s*, *s*. The height of the machine is about eight feet, the greatest diameter of the wheel *a b c d* is about seven inches and five-tenths, the depth of the groove upon its circumference about one-fourth of an inch, and the diameter of the friction rollers about five inches.

A pendulum PW is carried by the shelf RST. The plane of the dial plate is parallel to that of the wheel *a b c d*. Between the platform CD and the base *s s* of the pillar CQ there rises an upright EF, whose section is a rectangular parallelogram, the length of the sides being about one inch and six-tenths, and two inches and one-tenth. The narrowest face is parallel to that of the wheel *a b c d*, and carries a divided scale about 64 inches long, and subdivided into inches and tenths. The zero of the scale is in the horizontal plane passing by the point *l* of the short lever *g l*, in its primitive position below the weight A, (Plate CCCLXVIII. Figs. 7. and 8.) Three supports, one of which is represented at Z, slide freely upon the rule EF, and may be fixed at any point of it by means of a screw s', which presses a spring against the vertical face of the upright EF.

In the following account of the method of using this machine, we have implicitly followed the description given by Mr. Atwood himself.

Of the quantity of matter moved.—In order to observe the effects of the moving force, which is the object of any experiment, the interference of all other forces should be prevented; the quantity of matter moved, therefore, considering it before any impelling force has been applied, should be without weight; for though it be impossible to abstract weight from any substance whatever, yet it may be so counteracted as to produce no sensible effect. Thus in the machine (Plate CCCLXVIII. Fig. 1.) A, B, represent two equal weights affixed to the extremities of a very fine silk thread, stretched over a wheel or fixed pulley *a b c d*, moveable round a horizontal axis: the two weights A, B being equal, and acting against each other, remain in equilibrio; and when the least weight is superadded to either (setting aside the effects of friction), it will preponderate. When A, B are set in motion by the action of any weight m, the sum $A+B+m$ would constitute the whole mass moved, but for the inertia of the materials which must necessarily be used in the communication of motion. These materials consist of, 1. The wheel *a b c d*, over which the thread sustaining A and B passes. 2. The four friction-wheels on which the axle of the wheel *a b c d* rests. 3. The thread by which the bodies A and B are connected, so as when set in motion to move with equal velocities. The weight and inertia of the thread are too small to have any sensible effect on the experiments; but the inertia of the other materials constitute a considerable proportion of the mass moved, and must therefore be taken into account. Since when A and B are put in motion, they must move with a velocity equal to that of the circumference of the wheel *a b c d* to which the thread is applied; it follows, that if the whole mass of the wheels were accumulated in this circumference, its inertia would be truly estimated by the quantity of matter moved; but since the parts of the wheels move with different velocities, their effects in resisting the communication of motion to A and B by their inertia will be different; those parts which are furthest from the axis resisting more than those which revolve nearer in a duplicate proportion of those distances. If the figures of the wheels were regular, the distances of their centres of gyration from their axes of motion would be given, and consequently an equivalent weight, which, being accumulated uniformly in the circumference *a b c d*, would exert an inertia equal to that of the wheels in their constructed form, would also be given. But as the figures are irregular, recourse must be had to experiment, to assign that quantity of matter, which, being accumulated uniformly in the circumference of the wheel *a b c d*, would resist the communication of motion to A in the same manner as the wheels.

In order to ascertain the inertia of the wheel *a b c d* with that of the friction-wheels, the weights A B being removed, the following experiment was made:

A weight of 30 grains was affixed to a silk thread of inconsiderable weight; this thread being wound round the wheel *a b c d*, the weight 30 grains by descending from rest communicated motion to the wheel, and by many trials was observed to describe a space of about $38\frac{1}{2}$ inches in 3 seconds. From these data the equivalent mass or inertia of the wheels will be known from this rule.

Let a weight P, (Plate CCCLXVIII. Fig. 2.) be applied to communicate motion to a system of bodies by means of a very slender and flexible thread going round the wheel SLDIM, through the centre of which the axis passes, (G being the common centre of gravity, R the centre of gravity of the matter contained in this line, and O the centre of oscillation). Let this weight descend from rest through any convenient space s inches, and let the observed time of its descent be t seconds; then if l be the space through which bodies descend freely by gravity in one second, the equivalent weight sought

$$=\frac{W\times SR\times SO}{SD^2}=\frac{P\times t^2 l}{s}-P$$

Here we have $p=30$ grains, $t=3$ seconds, $l=193$ inches, $s=38.5$ inches; and $-\frac{P\times t^2 l}{s}-P=\frac{30\times 9\times 193}{385}$ $38=1323$ grains, or $2\frac{3}{4}$ ounces.

This is the inertia equivalent to that of the wheel *a b c d*, and the friction wheels together; for the rule extends to the estimation of the inertia of the mass contained in all the wheels.

The resistance to motion, therefore, arising from the wheel's inertia, will be the same as if they were absolutely removed, and a mass of $2\frac{1}{4}$ ounces uniformly accumulated in the circumference of the wheel *a b c d*. This being premised, let the boxes A and B be replaced, being suspended by the silk thread over the wheel or pulley *a b c d*, and balancing each other: suppose that any weight m be added to A so that it shall descend, the exact quantity of matter moved during the descent of the weight A will be ascertained; for the whole mas will be $A+B+m+2\frac{3}{4}$ oz.

In order to avoid troublesome computations in adjusting the quantities of matter moved and the moving forces, some determinate weight of convenient magnitude may be assumed as a standard, to which all the other are referred. This standard weight in the subsequent experiments is $\frac{1}{4}$ of an ounce, and is represented by the letter m. The inertia of the wheels being therefore $=2\frac{3}{4}$ ounces, will be denoted by $11\,m$. A and B are two boxes, constructed so as to contain different quantities of matter, according as the experiment may require them to be varied: the weight of each box, including the hook to which it is suspended $=1\frac{1}{2}$ oz. or, according to the preceding estimation, the weight of each box will be denoted by $6\,m$; these boxes contain such weights as are represented by Plate CCCLXVIII. Fig. 3. each of which weighs an ounce, so as to be equivalent to $4\,m$; other weights of $\frac{1}{2}$ oz. $=2\,m$, $\frac{1}{4}=m$, and aliquot parts of m, such as $\frac{1}{2}\,m$, $\frac{1}{4}\,m$, may be also included in the boxes, according to the conditions of the different experiments hereafter described.

If $4\frac{3}{4}$ oz. or $19\,m$, be included in either box, this with the weight of the box itself will be $25\,m$; so that when the weights A and B, each being $25\,m$, are balanced in the manner above represented, their whole mass will be $50\,m$, which being added to the inertia of the wheels $11\,m$, the sum will be $61\,m$. Moreover, three circular weights, such as that which is represented at Plate CCCLXVIII. Fig. 4. are constructed; each of which $=\frac{1}{4}$ oz. or m. If one of these be added to A, and one to B, the whole mass will now become $63\,m$, perfectly in equilibrio, and moveable by the least weight added to either, (setting aside the effects of friction,) in the same manner precisely as if the same weight or force were applied to communicate motion to the mass $63\,m$, existing in free space and without gravity.

2. *The moving Force.* Since the weight of any substance is constant, and the exact quantity of it easily estimated, it will be convenient here to apply a weight to the mass A as a moving force. Thus, when the system consists of a mass $=63\,m$, according to the preceding description, the whole being perfectly balanced, let a weight $\frac{1}{4}$ oz. or m, such as is represented in Plate CCCLXVIII. Fig. 5. be applied on the mass A; this will communicate motion to the whole system; by adding a quantity of matter m to the former mass $64\,m$, the whole quantity of matter moved will now become $63\,m$; and the moving force being $=m$, this will give the force which accelerates the descent of $A=\frac{m}{64}$, or $\frac{1}{64}$ part of the accelerating force of gravity.

By the preceding construction, the moving force may be altered without altering the mass moved; for suppose the three weights m, two of which are placed on A, and one on B, to be removed, then will A balance B. If the weights $3\,m$ be all placed on A, the moving force will become $3\,m$, and the mass moved $64\,m$, as before, and the force which accelerates the descent of A, $=\frac{3\,m}{64\,m}=\frac{3}{64}$ parts of the force by which gravity accelerates falling bodies.

Suppose it were required to make the moving force $2\,m$, the mass moved, continue the same. Let the three weights, each of which $= m$, be moved; A and B will balance each other; and the whole mass will be $61\,m$: let $\frac{1}{2}\,m$, (Plate CCCLXVIII. Fig. 5.) be added to A, and $\frac{1}{2}\,m$ to B, the equilibrium will be preserved, and the mass moved will be $62\,m$; now, let $2\,m$ be added to A, the moving force will be $2\,m$, and the mass moved $64\,m$, as before; wherefore the force of acceleration $= \frac{1}{32}$ part of the acceleration of gravity. These alterations in the moving force may be easily made in the more elementary experiments, there being no necessity for altering the contents of the boxes A and B: but the proportion and absolute quantities of the moving force and mass moved may be of any assigned magnitude, according to the conditions of the proposition to be illustrated.

3. *Of the space described*—The body A (Plate CCCLXVIII. Fig. 1.) descends in a vertical line; and a scale EF, about 64 inches in length, divided into inches and tenths, is adjusted vertical, and so placed that the descending weight A may fall in the middle of a square stage Z, fixed to receive it at the end of the descent: the beginning of the descent is estimated from 0 on the scale, when the bottom of the box A is on a level with 0. The descent of A is terminated when the bottom of the box strikes the stage Z, which may be fixed at different distances from the point 0; so that by altering the position of the stage, the space described from rest may be of any given magnitude less than 64 inches.

4. *The time of description* is observed by the pendulum XW vibrating seconds; and the experiments intended to illustrate the elementary propositions, may easily be so constructed that the time of motion shall be a whole number of seconds. The estimation of the time, therefore, admits of considerable exactness, provided the observer takes care to let the bottom of the box A begin its descent precisely at any beat of the pendulum; then the coincidence of the stroke of the box against the stage, and the beat of the pendulum at the end of the time of motion, will show how nearly the experiment and the theory agree. There might be various devices for letting the weight A begin its descent at the instant of a beat of the pendulum W; for instance, let the bottom of the box A, when at 0 on the scale, rest on a flat rod, held in the hand horizontally; its extremity being coincident with 0, by attending to the beats of the pendulum, and with a little practice, the rod which supports the box A may be removed at the moment the pendulum beats, so that the descent of A shall commence at the same instant.

In the machine constructed by M. Fortin, for the Physical Cabinet of the Faculty of Sciences at Paris, this ingenious artist has employed a detent, for the purpose of making the weight set out at the instant that the second hand marks 0″ on the dial plate.

In order to give an idea of this contrivance, we have represented the upper part of the machine with the detent annexed to it in Plate CCCLXVIII. Fig. 7. 8. where e, f are two pillars of brass, fixed below the platform CD, and supporting a horizontal axis $g\,h$, perpendicular to two arms of a lever, one of which is short, and destined to support the weight A in its first position, and the other longer.

This last lever, being at first detained by a catch, disengages itself, and when left to itself, it causes the axis $g\,h$ to turn, and the small lever which turns at the same time quits its first position, and then the weight A attached to the extremity of the thread, being no longer supported by the short lever, begins to move. The horizontal axis $g\,h$ is projected into g (Plate CCCLXVIII. Fig. 8.) which is a section at right angles to $g\,h$. The short and long lever, viz $g\,h$, $g\,k$, are represented by the dotted lines as in their primitive position, the first supporting the weight A, and in their second position by the continuous lines $g\,l'$, $g\,k'$, the extremity k of the longer lever having descended to k through the arc $k\,k'$, whose centre is g, and being detained at k' by a fork k (CCCLXVIII. Fig. 7 and 8)

We shall now proceed to explain how the extremity k of the long lever disengages itself at the instant when the second hand marks 0″ on the dial plate.

The platform which supports the pendulum carries a horizontal axis, to which is fixed a lever with two arms, an interior one $i\,m$ hid by the plate, and an exterior one $m\,n\,r$, formed of two parts $m\,n$, $n\,r$, united at r by a joint or pivot, round which the part $m\,n$ may turn. The other part $n\,r$, which is a plane surface, can only run horizontally in the groove of a pulley t. It is full at the end n, but is cut out at the other end r. A vertical iron rod can take two positions $v\,u$, $v'\,u'$, corresponding to the initial and final positions of the moveable plate $n\,r$. In the first position $v\,u$, it passes through the cut out part of the plate $n\,r$; and in the second position $v'\,u'$ its extremity bears upon the full part of this plate. When the iron rod is in the last position $v'\,u'$, the extremity k of the long lever $g\,k$ is engaged in the fork v', which terminates the vertical rod $u'\,v'$. A wiper seen in Fig. 10. fixed to the wheel of the pendulum, presses the extremity i of the lever $m\,i$. The point of junction n of the lever $m\,n$, and the plate $n\,r$, goes backward to n': the plate $n\,r$ slides horizontally in the same direction; the rod $v'\,u'$, being no longer supported by the full part of the plate $n\,r$, falls through the cut out part, and takes the position $v\,u$, where it is stopped by a horizontal rod $x\,x$ fixed between the upright pieces P x, $y'\,x'\,z$, which set out, the one from the box of the pendulum P, and the other from the horizontal branch RS of the shelf RST.

In order to bring the extremity of the long lever $g\,k$, or $g\,k'$, into the fork v of the vertical rod, there is attached to this end a thread, which passes first through the fork, and next through an eye z of the bent part of the upright $y'\,x'\,z$. Another thread attached to the fork passes into the same eye. By drawing successively these two threads, the plate $n\,r$ is pushed at r towards the upright $y'\,x'\,z$, and then the vertical rod $v'\,u'$ is supported by the full part of the plate $n\,r$.

The three armed levers $i\,m$, $m\,n$, $n\,r$, and the wiper of the ratchet wheel of the pendulum, are shown separately in Plate CCCLXVIII. Fig. 9. Whatever be the position of this wiper upon the wheel, it is easy to find the position which it is necessary to give to the seconds hand upon its axis. If we suppose that the seconds hand marks 15″ on the dial, when the detent sets out, or when the vertical rod which supports the end of the lever falls, we can turn the needle upon its axis through an arc corresponding to 15″ in a direction contrary to the motion of the ratchet wheel, and the seconds hands will mark 0″ when the wiper sets off the detent. See Hachette's *Traité des Machines*, p. 7.

5. *Of the velocity acquired.*—It remains only to describe in what manner the velocity acquired by the descending weight A, at any given point of its path, is made evident to the senses. The velocity of A's descent being continually accelerated will be the same in two points of the space described. This is occasioned by the constant action of the moving force; and since the velocity of A at any instant is measured by the space which would be described by it moving uniformly for a given time with the velocity it had acquired at that instant, this measure cannot be experimentally obtained, except by removing the force by which the descending body's acceleration was caused.

In order to show in what manner this is effected particularly, let us again suppose the boxes A and $B=25m$ each, so as together to be $=50\ m$; this with the wheel's inertia 11 m will make 61 m; now let m be added to A, and an equal weight m to B, these bodies will balance each other, and the whole mass will be 63 m. If a weight m be added to A, motion will be communicated. the moving force being m, and the mass moved 64 m. In estimating the moving force, the circular weight $=m$ was made use of as a moving force: but for the present purpose of showing the velocity acquired, it will be convenient to use a flat rod, the weight of which is also $=m$. Let the bottom of the box A be placed on a level with 0 on the scale, the whole mass being as described above $=63\ m$, perfectly balanced. Now let the rod, the weight of which $=m$, be placed on the upper surface of A; this body will descend along the scale in the same manner as when the moving force was applied in the form of a circular weight. Suppose the mass A, Fig 9. to have descended by constant acceleration of the force of m, for any given time, or through a given space: let a circular frame be so affixed to the scale, contiguous to which the weight descends, that A may pass centrally through it, and that this circular frame may intercept the rod m by which the body A has been accelerated from rest. After the moving force m has been intercepted at the end of the given space or time, there will be no force operating on any part of the system which can accelerate or retard its motion: this being the case, the weight A, the instant after m has been removed, must proceed uniformly with the velocity which it had acquired that instant: in the subsequent part of its descent, the velocity, being uniform, will be measured by space described in any convenient number of seconds.

Mr Atwood's machine is also useful for estimating experimentally the velocities communicated by the impact of bodies elastic and non elastic, and the quantity of resistance opposed by fluids. as well as for various other purposes. These uses we shall not consider at present; but the properties of retarded motion being a part of the present subject, it may be necessary to show in what manner the motion of bodies resisted by constant forces are reduced to experiment by means of the instrument above described, with as great ease and precision as the properties of bodies uniformly accelerated. A single instance will be sufficient: Thus, suppose the mass contained in the weights A and B, (Plate CCCLXVIII. Fig. 6) and the wheels to be 61 m, when perfectly in equilibrio; let a circular weight m be applied to B, and let two long weights or rods, each $=m$, be applied to A, then will A descend by the action of the moving force m, the mass moved being 64 m: suppose that when it has described any given space by constant acceleration, the two rods m are intercepted by the circular frame above described, while A is descending through it, the velocity acquired by that descent is known; and when the two rods are intercepted, the weight A will begin to move on with the velocity acquired, being now retarded by the constant force m; and since the mass moved is 62 m, the force of retardation will be $\frac{1}{62}$ part of that force whereby gravity retards bodies thrown perpendicularly upwards. The weight A will therefore proceed along the graduated scale in its descent, with an uniformly retarded motion, and the spaces described, times of motion, and velocities destroyed by the resisting force, will be subject to the same measures as in the examples of accelerated motion already described.

In the preceding description, as Mr. Atwood remarks, two suppositions have been assumed, neither of which is mathematically true: but it might be easily shown that they are so in a physical sense, the errors occasioned by them being insensible in practice.

1. The force which communicates motion to the system has been assumed constant; which will be true only on a supposition, that the line at the extremities of what the weights A and B, (Plate CCCLXVIII Fig. 1.) are affixed, is without weight. In order to make it evident that the lines, weight, and inertiæ, are of no sensible effect, let a case be referred to wherein the body A descends through 48 inches from rest, by the action of the moving force m, when the mass moved is 64 m; the time wherein A describes 48 inches, is increased by the effects of the line's weight, by no more than $\frac{312}{10000}$th parts of a second: the time of descent being 3.9896 seconds, when the string's weight is not considered, and the time when the string's weight is taken into account $=4.0208$ seconds; the difference between which is wholly insensible by observation.

2. The bodies have also been supposed to move in vacuo, whereas the resistance of the air will have some effect in retarding their motion; but as the greatest velocity communicated in these experiments cannot much exceed that of about 26 inches in a second, (suppose the limit 26.2845, and the cylindrical boxes $1\frac{3}{4}$ inches in diameter,) the resistance of the air can never increase the time of descent in so great proportion as that of 240 : 241; its effects will therefore be insensible in experiment.

The effects of friction are almost wholly removed by the friction-wheels, for when the surfaces are well polished, and free from dust, &c. if the weights A and B be balanced in perfect equilibrio, and the whole mass consists of 63 m, according to the example already described, a weight of $1\frac{1}{2}$ grains, or at most 2 grains, being added either to A or B, will communicate motion to the whole; which shows that the effects of friction will not be so great as a weight of $1\frac{1}{2}$ or 2 grains. In some cases, however, especially in experiments relating to retarded motion, the effects of friction become sensible; but may be very readily and exactly removed, by adding a small weight of 1.5 or 2 grains to the descending body, taking care that the weight added be such as is in the least degree smaller than that which is just sufficient to put the whole in motion when A and B are equal, and balance each other before the moving force is applied.

It is obvious that the motion of the two weights in the preceding machine, is a particular case of the problem, resolved by the application of D'Alembert's principle, in chap. viii. p. 637. It is the case when the two inclined planes have a vertical position, and consequently, when their lengths l and l' are equal to their heights h. If we therefore substitute in the formulæ there given, $l=l'=h$, and suppose the initial velocity $a=0$, we shall have,

$$v=\frac{M-M'}{M+M'}\times g\ t \text{ and}$$

$$x=\frac{M-M'}{M+M'}\times \frac{g\ t^2}{2}+b$$

by means of which we may compare the experimental results with the theory. The motion will be as much slower as the difference $M-M'$ of the two masses is smaller in relation to $M+M'$ their sum. See Poisson's *Traité de Mecanique*, p. 46.

SECT. II. *Mr. Smeaton's Machine for experiments on Rotatory Motion.*

The following ingenious apparatus was employed by Mr. Smeaton, in his "Experimental examination of the quantity and proportion of Mechanic Power necessary to be employed in giving different degrees of velocity to heavy bodies from a state of rest," with the view of showing that the same mechanic power is capable of producing the same velocity as a given body, whether it is applied so as to produce it in a greater or less time.

The machine is represented in Plate CCCLXIX. Fig. 1. AB is the base of the machine, placed upon a table; AC is a pillar, or standard; CD is an arm, on the extremity of which is fixed a plate *f g*, here seen edgeways, through which is a hole for receiving a small steel pivot, fixed on the top of the upright axis *e* B, the lower end of which axis terminates in a conical steel point, resting on a small cup of hard steel, polished at B:—HI is a cylinder of white fir, which, passing through, fixes in a perforation in the axis; and on the two arms, thus formed capable of sliding, are K, L, two cylindrical weights of lead of equal size, which, by means of two thin wedges of wood, are capable of being fixed on any part of the cylindrical arms from the axis to their extremities. The two weights, therefore, being at equal distances from the centre, and the axis perpendicular, the whole will be balanced on the point at B, and by an impelling power moveable on it with very little friction. On the upper part of the axis are formed two cylindrical barrels MN, of which M is double the diameter of N; and they have a little pin stuck into one side of each at *o*, *p*.

Q is a piece capable of sliding higher or lower as may be required; and carries R, a light pulley of about three inches diameter, hung on a steel axis, and moveable on two small pivots. The plane of the pulley, however, is not directed to the middle of the upright axis, but a little on one side, so as to point at a mean between the larger and lesser barrel. S is a light scale for receiving weights, and hangs by a small twine, cord, or line, that passes over the pulley, and terminates on either of the barrels as may be required: the sliding pin Q being moved higher or lower for each, so that the line, in passing from the pulley to the barrel, may be nearly horizontal. The end of the line farthest from the scale is terminated by a small loop, which hangs on the pin *o*, or the pin *p*, according as the larger or the lesser barrel is to be used.

Now, having wound up a certain number of turns of the line on the barrel, and having placed a weight in the scale S, it is obvious that it will cause the axis to turn round, and give motion to its arms, and to the weights of lead placed on them, which are heavy bodies to be put in motion by the impulse of the weight in the scale; and when the line is wound off to the pin, the loop slips off, and the scale falling down, the weight will cease to accelerate the motion of the heavy bodies, and leave them revolving equably forward with the velocity they have regained; except so far as that velocity must be gradually lessened by the friction of the machine, and the resistance of the air, which, being small, the bodies will revolve for some time before their velocity is apparently diminished.

The following are the dimensions of some parts of the machine:

Diameter of the cylinders of lead, or of the heavy bodies, ...	2.57
Length of ditto, ...	1.56
Diameter of the hole in them, . .	.72
The weight of each cylinder is 3 lbs. avoirdupois.	
Greater distance of the middle of each body from the centre of the axis, . .	8.25
The smaller distance, ditto, . . .	3.92
Ten turns of the smaller barrel, or five of the larger, raises the scale. . .	25.25

When the bodies are at the smaller distance from the axis of rotation, they are then in effect at half the greater distance from that axis; for, since the axis itself, and the cylindrical arms of wood, keep an unvariable distance from the centre of rotation, the bodies themselves must be moved nearer than half their former distance, that, by being compounded with the invariable parts, they may be virtually at the half distance. In order to find this half distance nearly, an arm was put in of the same wood, that only passed through the axis, without extending in the opposite direction; one of the bodies being attached to the end of this arm, at the distance of 8.25 inches, the whole machine was inclined till the body and arm became a kind of pendulum, making 92 vibrations in the minute; and, as a pendulum of the half length vibrates quicker in the proportion of $\sqrt{1}$ to $\sqrt{2}$, that is, in the proportion nearly of 92 to 130; therefore, keeping the same inclination of the machine, the weight was moved on the arm, till it made 130 vibrations in the minute, which was found to be as above stated, when it was at 3.92 inches distance from the centre; which is about $\frac{2}{10}$ths of an inch nearer than the half distance. The double arm was then put in, and marked accordingly; and the bodies being mounted on it, the whole was adjusted ready for use, and with it were tried the following experiments: each of which was repeated so many times as to prove fully satisfactory.

Table of Experiments.

Number	Ounces avoirdupois in the scale.	Barrel used. M the larger, N the smaller.	The arms. W the whole, H the half length.	Number of turns of the line wound on the barrel.	Time of the descent of the weight in the scale.	Time of making 20 revolutions with equable motion.
1	8	M	W	5	14¼ sec.	29 sec.
2	8	N	W	10	28¼	29¼
3	8	N	W	2½	14¼	58½
4	32	M	W	5	7	4
5	32	N	W	10	14	14¾
6	32	N	W	2½	7	28¾
7	8	M	H	5	7	14¾
8	8	N	H	10	14	15
9	8	N	H	2½	7	30¼
1	2	3	4	5	6	7

The 58½ seconds, in number 3, column 7, was determined, in fact, from 29¼ seconds, being the time of making 10 equable revolutions after the weight was dropped off, in order to prevent the sensible retardation that might take place and affect the observation, if continued for 20 revolutions made so slowly. *Phil. Trans.* 1776, p. 450.

SECT. III. *Smeaton's apparatus for experiments on Windmill sails.*

In making the series of experiments on windmill sails of which we have already given the results, Mr. Smeaton employed the apparatus represented in Plate CCCLXIX. Fig. 2. Having found that the wind itself was too uncertain for such experiments, he had recourse to wind created artificially. This could obviously be done in two ways; either by causing the air to move against the machine, or the machine against the air. The first of these methods was not easily put in practice, and he therefore adopted the second; but as it required a large room to carry the machine forward against the air, he resolved to carry the axis on which the sails were to be fixed progressively round in the circumference of a large circle. Upon this principle, the machine represented in Fig. 2. was constructed. ABC is a pyramidal frame for supporting the moving parts. DE is an upright axis, upon which is framed FG, an arm for carrying the sails at a proper distance from the centre of the upright axis. H is a barrel upon the upright axis, round which is wound a cord; which, being drawn by the hand, gives a circular motion to the axis, and to the arm FG; and thereby carries the axis of the sails in the circumference of a circle whose radius is DI, causing thereby the sails to strike the air, and turn round upon their own axis.

At L is fixed the end of a small line, which, passing through the pulleys MNO, terminates upon a small cylinder or barrel upon the axis of the sails, and by winding thereon raises P, the scale wherein the weights are placed for trying the power of the sails. This scale, moving up and down in the direction of the upright axis, receives no disturbance from the circular motion. Q, R are two parallel pillars, standing upon the arm FG, for the purpose of supporting and keeping steady the scale P, which is kept from swinging by means of S, T, two small chains which hang loosely round the two pillars.

The weight W brings the centre of gravity, and the moveable part of the machine, into the centre of motion of the axis DE.

A pendulum VX, composed of two balls of lead, which are moveable upon a wooden rod, can be so adjusted as to vibrate in any time required. This pendulum hangs upon a cylindrical wire, upon which it vibrates as on a rolling axis.

A perforated table Y supports the axis of the pendulum; the pendulum being so adjusted as to make two vibrations in the time that the arm FG is intended to make one turn: The pendulum being set a vibrating, the experimenter pulls by the cord Z, with sufficient force to make each half revolution of the arm to correspond with each vibration as equal as possible, during the number of vibrations that the experiment is intended to be continued. A little practice renders it easy to give motion to it, with all the regularity that is necessary. See *Phil. Trans.* 1759, p. 139.

SECT. IV. *Machine in which all the Mechanical Powers are united.*

This machine is represented in Plate CCCLXIX. Fig. 3. where ABCD is a frame fastened upon the stand O *o* by the nut *o*, and kept together by the pillars VW and B *q*. The piece EF is first fitted to the frame, having vanes E, F, which may be either moved by the wind, or by a cord fastened at F. This part represents the lever, whose fulcrum is G. A perpendicular axis GH is joined to this lever, and carries the endless screw H, which may be considered as a wedge. This endless screw works in the teeth of the wheel K, which is the wheel and axle; and when K is turned round, it winds up on the axle IL the cord LM, which, passing round the tackle of pulleys MN, raises the weight P. In order to include the inclined plane in this combination, we must add the plane RQ *r q*, and make it rest on the ground at QR, and on the pillar B *q* at *q r*. When the weight P is placed on this plane, the power will be farther increased in the ratio of QT to TS. The power gained by this combination will be found by comparing the space described by the point F, with the height through which the weight rises in any determinate number of revolutions of F. See *Desaguliers*, vol. i. p. 128.

SECT. V. *Machine for illustrating the Theory of the Wedge.*

This machine is represented in Plate CCCLXIX. Fig. 4. where KILM and LMNO are two flat pieces of wood, each about 15 inches long, and 3 or 4 broad, joined together by a hinge at LM; P is a graduated arch of brass, on which these pieces of wood can be moved so as to subtend any angle not greater than 60°, and *a*, *b*, two screws for fixing them at the required angle. The back of the wedge will therefore be represented by IKNO, its sharp edge, which enters the wood, by LM, and its two sides, against which the wood acts in cleaving, by KILM, LMNO. The weight *p* suspended to the wedge by the hook M, and the weight of the wedge itself, may be considered as the force employed to drive the wedge. The wooden cylinders AB, CD, have their extremities made like two flat circular plates, to prevent the wedge from slipping off at one side. To the pivots of these cylinders, two of which are represented at e and f, are fastened the cords e W, f U, CV, AX, which, passing over the pulleys U, V, X, W, are fastened to the two bars $u\ v$, $x\ w$, on which any equal weights Y, Z, may be hung at pleasure. The tendency of these weights is evidently to draw the cylinders towards each other; and they may therefore be considered as the resistance of the wood acting against opposite sides of the wedge. The cylinders themselves are suspended by their pivots and loops on the threads E, F, G, H, which may be fixed to hooks in the ceiling of the room, or to the horizontal beam of a frame made on purpose. By placing various equal weights at Y and Z, it may be easy to determine the proportion between the power and the resistance when the wedge is in equilibrio. In this machine, the impelling power is the pressure of the weight p; whereas, in the real wedge, the impelling power is always an impulsive force, which is infinitely more powerful. See Ferguson's *Lectures*, vol. i. p. 79.

SECT. VI. *Machine for showing how the Compression of the Earth's Poles is produced by the Centrifugal Force.*

This machine is represented in Plate CCCLXIX. Fig. 5. It consists of two circular hoops AB and CD, made thin and flexible, and crossing one another at right angles. These hoops are fixed to the vertical axis EF at its lower extremity; but they are left quite free of the axis at the upper end. If a rapid motion is given to this axis by means of the winch M, and the wheel and pinion N, O, the middle parts ABCD of the hoops will swell out, and strike against the sides of the frame at F and G, provided the pole e, in reaching to the pin E, is not prevented by it from sinking farther. The hoops, therefore, will have a spheroidal form, the equatorial being considerably larger than the polar diameter. See Ferguson's *Lectures*, vol. i. p. 55.

SECT. VII. *Machine for explaining the Composition of Forces.*

This machine consists of a wooden square ABCD, (Plate CCCLXIX. Fig. 6.) so contrived as to have the part BEFC made to draw out or push into the square at pleasure. To this part is joined the pulley H, so as to turn freely on an axis, which will be at H when the piece is pushed in, and at h when it is drawn out. The ends of a straight wire k are fixed to this part, so as to move along with it under the pulley, and the ball G is made to slide easily on the wire. A thread m attached to this ball passes over the pulley to I; and, by means of this thread, the ball may be drawn up on the wire parallel to the side AD, when the part BEFC is pushed into the square as far as possible. But if this part be drawn out, it will carry the ball along with it parallel to the bottom of the square DC. The ball G will in this way be either drawn perpendicularly upward by pulling the thread m, or moved horizontally along by pulling out the part BEFC, in equal times and through equal spaces, each power acting upon it equally and separately. But if, when the ball is at G, the upper end of the thread be tied to the pin I in the corner A of the fixed square, and the moveable part BEFC be drawn out, the ball will then be acted upon by both the powers together; for it will be drawn up by the thread to the top of the square, and at the same time be carried with its wire k towards the right hand BC, moving all the while in the diagonal line L, and will be found at g when the sliding part is drawn out as far as it was before. This part has therefore caused the thread to draw up the ball to the top of the inside of the square, just as high as it was before when drawn up singly by the thread, without moving the sliding part. See Ferguson's *Lectures*, vol. i. p. 28, 29.

SECT. VIII. *Machine for trying the Strength of Materials.*

In this machine, which is shown in Plate CCCLXIX. Fig. 7. EF represents the piece of wood whose strength is to be determined. It is held by a double vice IK with four screws, two of which hide the other two in the figure. The power is applied by turning the winch A fixed on the axis RS. A rope fixed to the pulley B, and passing between the pulleys m, n, is attached at C to the piece D, fastened at the point where the force is to be exerted. The pulleys m, n, slide on the two parallel bars $a\ b$, $c\ d$, fixed on a frame which is held down by a projecting point at G in the lever GH, which is graduated like a steelyard, for the purpose of measuring the intensity of the force applied. When the strength of a wire is to be tried, it must be fixed to the cross bar LM; and when any substance is to be crushed, it must be placed beneath the lever NO, the pulleys m, n, and B, being slipped towards the ends b, d, S, the end N receiving the rope BC, and the end O being held down by the click which acts upon the double-ratchet OP. The lever is double from O to Q, and acts upon the body by a loop fixed to it by a pin. See Dr. Young's *Nat. Phil.* vol. i.

SECT. IX. *Coulomb's Apparatus for measuring the Flexion of Plates.*

This apparatus has already been described in p. 632 of this article, and represented in Plate CCCLXIV. Fig. 7.

SECT. X. *Coulomb's Torsion Balance.*

This machine has already been described in p. 628 of this article, and, under different forms, under ELECTRICITY, and Plate CCXLIV. Fig. 7, 8, 9, 10. &c.; HYDRODYNAMICS, and Plate CCCXIX. Fig. 4; and MAGNETISM, and Plate CCCLI. Fig. 18.

SECT. XI. *Gravesende's Machine for measuring the Elasticty of Bodies.*

The apparatus employed by Gravesende for this purpose, is represented in Plate CCCLXIX. Fig. 8. It consists of a frame ABCD, which carries the pincers or vices M, N, between which is fastened the wire or rod of steel, or any other substance MN, whose elasticity is to be tried. A scale S, carrying weights, is fixed to a piece of metal PQ, perforated at Q, so as to permit the wire or rod to pass through it. To the upper end of this piece is fixed a silk thread QR passing over the pulley R, and suspending a weight W, exactly equal to the weight of the piece PQ. The axis of this pulley carries the index V, which points to the divisions of a dial plate. If we now put different weights into the scale S, the elastic body MN will be bent by the weight, the middle point Q will descend, drawing after it the thread QR, and consequently turning the index TV from right to left. In order to know the exact space through which the point Q has descended, or the degree of flexure of the body MN, we must determine by direct experiment the relation between the divisions on the dial plate and the descent of any part of the thread QR. By this apparatus Gravesende determined the degree of flexure, or the descent of the middle points of the wires produced by various weights placed in the scale S. An account of his experiments will be found in his *Element. Phys.* and a very interesting generalisation of them in Biot's *Traité de Physique*, tom. i. p. 470.

SECT. XII. *Dr. Brewster's Chromatic Teinometer.*

Athough this instrument for measuring the elasticity of bodies acts upon optical and not upon mechanical principles, yet as it measures mechanical effects, it may be proper to explain it under the present article.

If a plate of glass is bent, and polarised light is transmitted through its edge, and analyzed by a prism of calcareous spar, a series of colours are exhibited, which depend on the degree of flexure of the glass plate, and are therefore measures of that flexure. When two plates of glass AB, CD, Plate CCCLXIX. Fig. 9. of different thicknesses, are pressed together at MN, they are found to give tints which are inversely as the squares of the thicknesses of the plates. The thickness of AB was 0.133 of an inch, and its tint 3.4 of Newton's scale; and CD was 0.23 of an inch thick, and its tint 10.2; and $133^2 : 230^2 = 3.4 : 10.2$ nearly. Now this principle is the foundation of the Teinometer. The tints of AB and CD are obviously measures of the elasticities of the two plates, so that the elasticities of plates of glass of different dimensions, and of different kinds, may thus be readily determined. The power of the instrument, however, is not limited to glass; for by using a glass plate AB as a standard, the other plate CD may be a plate of metal, or any other opaque substance, whose elasticity it is required to ascertain. The tint of AB, when opposed by a plate of equal elasticity, is known by experiment; and therefore the tint which it affords, when opposed by a similar plate of a substance possessing a greater or a less elasticity, affords a measure of this elasticity. Although the variation of the tint is an excellent means of determining the degree of curvature, yet the principle of exhibiting the relative elasticities of two plates by the application of the same force, may be employed in an *instrument entirely mechanical*, in which the *sagitta* of the inflected plate is actually measured; as in the machine of Gravesende's already described.

The *Chromatic Teinometer* is represented in Plate CCCLXIX. Fig. 10. 11. and 12. where AB is the standard plate of well annealed glass, having its edges parallel, and also flatly ground and well polished. Along this plate there are moved two brass pieces S *a b c*, S′*a*′*b*′*c*′, which can be fixed in any position by means of the screws S, S′. The plate CD, whose elasticity is to be measured, rests with its lower edge upon the projection *b c*, Fig. 11. and with one of its faces against *a b*. It is then pressed into contact with the plate AB, and kept in this position by the wooden holdfast H, the brass pieces S *a b c*, S′*a*′*b*′*c*′, having been previously placed at such a distance from each other, that the two plates will meet at H without breaking, or without any permanent change of form. The apparatus ER, for observing the tint, is shown separately in Fig. 12. It consists of an eye-piece E, to which is attached a reflector R, made of several plates of the thinnest glass, about $1\frac{1}{2}$ inch long and one inch broad, and placed close to each other. The eye-piece E consists of two tubes, one of which is moveable within the other. The moveable tube contains an achromatic prism *m n* of calcareous spar, with a convex lens *o p* about an inch in focal length, placed either above or below it. When this apparatus is set upon the edge of AB by means of the forked arms *e f*, the reflector R is turned round till the plane of reflection is cut at an angle of 45° by the plane of the plate AB, and is placed at such an angle that the light which it reflects through the edge of the plate AB, and up the tube, is completely polarised. The moveable tube is then turned round till the tints appear upon the edge of one of the images of the glass plate. In order to avoid the confusion arising from two images, the achromatic prism may be constructed in such a manner that only one of the images is visible.* See the *Edinburgh Transactions*, vol. viii.

SECT. XIII. *Coulomb's Apparatus for experiments on Friction.*

This apparatus, by which M. Coulomb obtained the interesting results respecting friction which we have already explained, is represented in Plate CCCLXX. Fig. 1. It consists of a solid table, supported by legs of great strength. The plank *c c*′ *d d*′, Fig. 1. and *d d*′, Fig. 2. of which the table is formed, is 8 feet long, 2 feet wide, and 3 inches thick. Upon this table are placed two pieces of oak AB, A′B′, 12 feet long and eight inches thick, lying in the direction of the table's length, and three inches distant from one another. In the space between the two extremities B, B′ of these pieces is placed a pulley H, of very hard wood, one foot in diameter, and weighing fourteen pounds. This pulley turns upon an axis of green oak ten lines in diameter. A cord, attached to a sledge S, Fig. 2. which runs upon the table, passes over this pulley, and suspends a scale P for containing weights, which can descend into a pit four feet deep, cut out beneath the pulley. At the other end AA of the pieces of wood AB, AB, is placed a small horizontal wheel and axle. Another plank *a a*′ *b b*′, 8 feet long, 16 inches wide, and 3 inches thick, is firmly fixed upon the pieces of wood AB, A′B′, its upper surface being very carefully planed. Upon this plank, sledges of the form shown in No. 1 and No. 2, are made to slide. ABDC, No. 1, is a plank eighteen inches wide, but of variable length. Beneath this plank are nailed two pieces AC *m m*′, BD *n n*′, so that when the sledge is placed upon the fixed plank *a a*′ *b*·*b*′, it may be retained on both sides by these pieces, with a play of two or three lines, in order that it may follow without any obstruction the direction of the plank. When it is required to diminish the touching surfaces, other pieces of different widths are nailed upon the plank ABDC, and their ends rounded for receiving the nuts, in order that they may not rub upon the plank. The two hooks *h*, *h*′, seen in No. 2, as fixed to the two extremities of the sledge, are used, the one for attaching the cord which suspends the pulley P, and the other for fixing the cord which goes round the wheel and axle, which is employed for bringing back the sledge to the side AA′ of the apparatus.

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* See *Philosophical Transactions*, 1819, p. 148

In some of the experiments the weight was obtained from a steelyard, as shown in Fig. 2. See *Mem. des Sçavans Etrangers*, tom. x. p. 167.

CHAP. II.

The mechanical contrivances and methods described in the following chapter are of a general nature, and may be applied to machines for various purposes.

Sect. I. *Hachette's Dynamometrical Machine.*

The object of the dynamometrical machine, invented by M. Hachette, is to measure pressures or draughts greater than those which can be estimated by a common dynamometer, or by any spring steelyard.

Let AB, (Plate CCCLXX. Fig. 3.) be the section of a moving axle driven by water, or by any other mechanical agent, and let it be required to measure its tangential resistance. Upon AB let us suppose a wheel DEFGH fixed, which turns along with the axis, and let another wheel *d e f g h*, with the same number of radii, turn freely upon the same axle. Springs D*d*, E*e* &c. are attached to each pair of radii CD, C *d*; CE, C *e*, &c. so that the attached points D, *d*, of the extremities of any of the springs, are in a plane perpendicular to the axis of rotation, and also equidistant from it. If the power is now applied in such a manner that the wheel *d e f g h* turns in the direction indicated by the arrow X, it is obvious that the extremities *d*, *e*, *f*, *g* of the springs fixed to this wheel will separate from the point D, E, F, &c.; that the equal angles DC *d*, EC *e*, FC *f*, whose sides pass by the extremities of the springs considered in their primitive position, will become other equal angles DC *d′* EC *e′*, FC *f′*, &c.; and that all the springs, if not equally stretched, will be stretched to the same angle. When the total tension of the springs is equal to the tangential resistance of the turning axle, the system of the two wheels will turn on the axle AB as a single wheel. If the axle turns, and if we can measure one of the angles DC *d′*, we shall have in the triangle DC *d′* the angle C, the equal sides CD, C *d′*; and consequently, the perpendiculars let fall from the centre C upon the side D *d′*, or the radius of the circle, to which the force which stretches the spring is a tangent. By observing, too, the number of turns of the axle in a given time, we shall have the velocity of the point, where the force which stretches each spring is applied. This velocity being multiplied by the sum of the tensions of the springs, the product will be the dynamical effect of the moving axle AB in one second.

In order to measure the angle DC *d′*, two small hammers *a*, *b*, are fixed on the middle lines of the radii C *d′*, CD, joined by any spring D *d′*. Each of these hammers will move in a plane perpendicular to the axis of rotation C, and at distances either equal or unequal from that axis, but greater than the radii of the wheels. These hammers strike two bells, placed without on the circumference described by the points *a* and *b*. The time between two consecutive sounds, arising from the blow of each of the hammers *a*, *b* is then measured by a seconds watch; and as the time of a complete revolution of the hammers is known, these two times will be to one another as the arch which measures the angles of the straight lines, which pass by the extremities of each spring to the entire circumference. This angle being known, we may easily measure separately the weight which stretches each spring under a known angle, and the sum of all these weights will be the total tension of the dynamometrical machine. If the springs are susceptible only of a tension of 1000 kilogrammes, and if eight springs are placed upon the same circumference, whose radius is one metre, and eight others upon a concentric circumference of a radius of eight decimetres, then, supposing that the axle makes four turns in a minute, the dynamometrical machines will show, that the force applied to the axle is nearly equivalent to that of 80 horses, the power of a horse being nearly 6000 dynamical units, as described in p. 643.

As the preceding apparatus must be attached to every axle whose tangential force it is required to determine, M. Hachette has given the following method of making the machine portable. In this case, the system of two wheels, represented in Fig. 3. must be regarded as the machine, and must be fixed upon a framing of carpentry, which stands firmly upon the ground, and opposite the middle of the length of the moving axle A′C′B, whose tangential force is required. In order to do this, we must apply a factitious resistance to the arbor ACB of the dynamometrical machine. This may be done in various ways. The axle ACB, Fig. 8. for example, may have its motion retarded, by making it move between the four blocks *p*, *q*, *r*, *s*, fixed to the bars MN, KL, and the resistance may be increased, by pressing the blocks firmer against the moving axle, by turning the nuts M, N. The resistance may obviously be increased to any extent, by using several of these frames. Now, in order to measure the useful resistance of the moving axle A′B′C′, we must first ascertain its velocity of rotation, or the number of its revolutions in a minute, when it is under the influence of this resistance. The axle A′B′C′ must then be disengaged from the machinery which it drives, and its motion communicated to the toothed wheel R, or *d e f g*, by the pinion V. A factitious resistance must then be produced upon the axle ACB of the machine, till the velocity of A′C′B′ is reduced to that which it had when doing work. The springs D *d*, &c. will give the magnitude of the resistance applied to the axle ABC of the wheel R, and consequently the useful resistance of the axle A′C′B′, which is equal to it.

If a factitious resistance of sufficient magnitude cannot be procured, the total value of the useful resistance may be deduced by a very simple calculation from the measure of a part of it. Let us suppose, that by interrupting the communication between any of the machinery and the turning axle A′C′B, the resistance and velocity of this axle has been diminished. Then we must make it drive the wheel R, whose axis is retarded by an artificial resistance, and find the resistance which will restore to ACB its primitive velocity. Let X be the total resistance applied to the axle at the extremity of a radius 1, F the factitious resistance which restores to it its primitive velocity. By diminishing the number of wheels driven by this axle, let the total resistance X be reduced to X′, then the two resistances X, X′ are obviously in the known ratio of the number of wheels which the axle turns. Hence $X' = n\,X$, n being a given number. But $X = X' + F$, since the axle of the power submitted to the resistance X, or to the sum of the two resistances X′ and F, turns with equal velocity. It follows, therefore, that $X = n X + F$, or $X = \frac{F}{1-n}$. The measured resistance F obviously comprehends the inertia and the friction, which proceed from the communication of motion from the axle of the power to the axle of the dynamometrical machine, and which is added to the factitious resistance. See *Bulletin de la Societé d'Encouragement*, Jan. 1812: and Hachette's *Traité des Machines*, p. 33.

SECT. II. *Prony's Apparatus for converting continuous circular Motions into rectilineal alternating Motions of a given length.*

This apparatus is represented in Plate CCCLXX. Fig. 5 where AB is a horizontal wheel fixed to a vertical axle CD put in motion by the first mover. This wheel works in two pinions *a b*, *a'b'*, placed at the extremities of the axis *d e*, but which are capable of turning freely upon this axis upon the collet *f g* It is easy to see, that the wheel AB, when it acts upon these pinions when they are not fixed upon their collets, ought not to produce any effect on the weight to be raised; but that if we can by any means fix one of these pinions upon the axis, the rotation of this pinion will give motion to the pulley *p p*, and consequently cause one of the buckets to rise. If, after the ascent of the bucket, we can contrive to disengage the fixed pinion from its axis, it will then have no influence in turning the pulley, and if we now fix the other pinion to the axis, the pulley will be turned by its action, and a contrary motion will be communicated, or the bucket which formerly ascended will now descend. In order to fix the pinions *a b*, *a' b'*, alternately upon the axis, when each of the buckets has reached its destination, a rod *h k* is made by means of the pieces *l m*, *l' m'*, to have a progressive motion along the axis *d e*. This rod carries at *m* and *n* small projecting pieces or clicks, which go into the teeth of the ratchet wheel *n q*, fixed on the faces of the pinions. Hence, if the rod *h k* advances in any direction, it will alternately fix itself with one of the two pinions, the other remaining free, and the axis *d e* will turn successively in opposite directions.

In order to make this alternation of motion correspond to the emptying of buckets, the rod *h k* extends beyond the gudgeon of the axis *d e*, which is pierced longitudinally. There is also an opening *r s* formed in the lever EF, which carries at its extremity the lenticular weight G. If this weight is supposed to have a motion from right to left, the lever EF will strike alternately the shoulders *k*, *k'*, and consequently produce the alternate motion of the rod *h k*, and the successive fixing of each of the pinions *a b*, *a'b'*, which produces the alternate rise and descent of the buckets. We have only, therefore, to employ the buckets themselves to give the oscillatory motion to the weight G. and this is easily done by means of forks *t*, *t*, (Plate CCCLXX Fig. 6) one of which is fixed to the horizontal axis HK, while the other, turning round a particular axis in H', gives motion to a second lever *x y*, fixed to the axis HK, and which gives it its motion. The first bucket which arrives at the top of the well, begins at first to empty itself by means of the hook *z*. It then meets the fork which corresponds to it, and gives to the weight G a vibrating motion, which frees one pinion from its axis, and fixes the other, and produces at the same instant the inverse motion of the axis *d e*, and of the pulley and bucket. The buckets have, as is shown in Fig. 5 a valve in the bottom, and are suspended a little above their centre of gravity when they are full, and their upper rim is curved as shown in the Figure.

When the bucket is suspended by a rope, it would not meet the hook in that point of its rim, which is equidistant from its two points of suspension, if the rope was in any way twisted; but by means of the curvature of the upper rim, the hook will slide along the curve to the lowest point of it, which is equi-distant from the points of suspension; and hence, in whatever way the bucket first meets the hook, the emptying will, in all cases, take place regularly, and without any waste of water As the longitudinal perforation of the extremity of the axis requires good workmen, Prony has given the following simple construction of an axis, which will produce the same effect as the preceding without being bored. The axis *d e* is of one piece, and made square in that part of its length which is comprehended between the pinions *a b*, *a' b'*. A piece *m m' k' k* may run along this square part, by means of two square apertures, formed at the extremities *m k*, *m' k'*, and carries clicks *m*. *m'*, destined to engage alternately in the teeth of the ratchet-wheels *n' q'*, *n q*. In the middle of the piece *m' m*. *k k'*. is fixed a shoulder *v y*. *y' v'*. so that a fork, working between *v y* and *v' y'*, might strike against *v y* and *v' y'* in its oscillations, and give an alternate motion to the piece *m m'*, *k'*. *k*. and consequently engage and disengage successively each of the clicks. In this new arrangement, the axis HK ought to be placed below the toothed wheel A B. towards the middle of the axis *d e*, and the levers *t*, *t'* must have a position the inverse of that represented in Fig. 5.

In order to have a general idea of the ratio between the dimensions of the machine, the effort of the first mover, and the weight to be raised, let

$F =$ effort of the mover.
$\varphi =$ the part of this effort consumed, and the proper motions of the machine.
$P =$ the weights to be raised.
$R =$ the radius of the lever by which the power acts.
$r =$ the radius of the pulley.
$n =$ the number of teeth in the wheel AB.
$n' =$ the number of leaves in one of the pinions *a b* or *a' b'*,

we shall have the equation $\frac{P}{F-\varphi} = \frac{n'}{n} \times \frac{R}{r}$, by means of which we may determine, in different cases, the quantities which ought to be given by means of others. The value of φ must be deduced from the known experiments upon friction, and the rigidity of cords and chains. See the *Mémoires de l' Institut*, tom. ii p. 216, and the *Annales des Arts et Manufactures*, tom. xix. p. 191, where the apparatus is described, with another improvement.

The preceding contrivance is similar in principle to one described in Emerson's *Mechanics*. A face wheel drives alternately two pinions fixed upon the same horizontal axle, and the pinions are alternately locked and unlocked by different contrivances.

SECT III.—*Betancourt's apparatus for converting continuous circular motions into rectilineal alternating motions of a given length.*

This machine is represented in Plate CCCLXX. Fig 8. where *a b* is an arbor, turning round its axis by any power, such as that of wind, &c. applied at *a*. Its pivot b rests on a piece of wood c, furnished with two rollers, which enter into a groove cut out of the cross piece $n'\,m'$, so that the arbor $a\,b$ can easily approach in succession the toothed wheels F, G, which are alternately caught by the endless screw h fixed upon the axis $a\,b$. The arbor $a\,b$ is supported by two cross pieces C, L, without restraining the small oscillatory motion which it ought to receive from the moveable piece c.

To the piece c are fixed two clicks $a'\,b'$, $c\,d$, which turn round their axes a' and c, and which, as well as the two arms b and d which are placed upon their extremities, are prolonged so as to reach the plane of the metallic piece $m\,u\,n$, seen more distinctly in Plate CCCLXX. Fig. 9. This piece has an axis $g\,f$, carrying two other branches $l\,i$, terminating in the shape of a fork, in order to allow the cords which carry the buckets to pass. Near the extremity g is a rod which carries a weight P, and in the cross piece $n'\,m'$ are two pins $x\,y$, whose projection is equal to the thickness of two clicks $a'\,b'$, $c\,d$. When two buckets are attached to the ends of a cord passing over the cylinders of the two wheels F, G, and coiled once round each, the machine will act in the following manner. In the position represented by the Figure, the arm u, after having pushed the pin a' towards the left, causes the endless screw h to drive the toothed wheel F, and the click $a'\,b'$ falling by its own weight, engages with a pin x, and presses the arbor against the toothed wheel.

When the button s, which is near the bucket S, is engaged in the fork l, the piece $u\,m\,n$ is forced to turn upon its axis, and the arm n, touching the handle b, unlocks the click before taking a horizontal position; but scarcely has it passed this position when the counterweight P, falling on the other side, the arm u pushes the pin c, and carries to the right hand the vertical axis $a\,b$, which makes the endless screw engage with the wheel G, while the click $c\,d$, by its own weight, engages with the pin y. The two cylinders turn in opposite directions, and the bucket S descends while the other ascends, and so on successively. The rims of the buckets are furnished with a piece of iron, in order to oblige them to take a situation proper for discharging water. See Lanz and Betancourt's *Essai sur la composition des Machines*, pp. 82, 83.

SECT. IV.—*Brunelle's Method of stopping Machinery, when the effect of the resistance in a Machine is increased by any unforeseen cause.*

It is of the greatest consequence for the preservation of machinery of all kinds, that it should cease to perform its work when the resistance is, by any unforeseen cause, suddenly increased. This is particularly requisite in machinery working with great force and velocity, as any sudden change in the state of the machine could scarcely fail to destroy the communicating parts. The block machinery at Portsmouth, invented by Mr. Brunelle, the most skilful mechanician of the present age, was particularly liable to this risk; and in order to guard the machinery from the danger to which it was thus exposed, he adopted the following expedient. The wheels, instead of forming one piece with their axles, or being fixed to them by bolts and screws, were made with a hollow conical shoulder, which fitted upon a conical part of the axle. By driving the interior upon the exterior cone with a hammer, the wheel was so united to its axle by *friction*, as to be incapable of turning upon it while performing its ordinary work; but when, from any accident, the force applied to the wheel was suddenly increased, this force, instead of hurting the machinery, overcame the friction between the two cones, and the wheel revolved upon its axle without turning it, and consequently without producing any injurious effect upon the machinery. As soon as the accident was over, the wheel was again driven upon the conical shoulder of its axle, and it went on performing its work as formerly.

SECT. V. *Prony's Apparatus for Unyoking Horses, when the effect of the resistance is increased by any unforeseen cause.*

In the apparatus represented in Plate CCCLXX. Fig. 10. the ropes $a, a, a, b\,b$ pass through the apertures b, b, formed in the frame d, d, attached to the extremity of the lever $c\,c$, which is fixed to the vertical axle employed to give motion to the machine; the apertures $b\,b$ being lined with friction pulleys. The extremity of each rope terminates in an eye which lays hold of a pin in the arbor e, moveable upon pivots. Round this arbor e is lapped a rope, which afterwards passes over the pulleys p, p, p, and suspends a weight w along the vertical arbor. This weight, which can be varied at pleasure, determines the resistance which we wish to oppose to the efforts of the animal. If we now suppose that this weight is limited to 20 pounds, and that a stick falls so as to obstruct the working of the pinion, it will follow that the action of the horse would break the machine, if it were not furnished with this mechanism: but as the effort necessarily exceeds the regulating weight w, the arbor e will be forced to describe a quarter of a circle, the pins having then quitted their vertical position, the extremities of the ropes, which were there united, escape from one another, the animal is freed, and the mechanism suffers no injury. This apparatus may also be employed to prevent horses employed to drive machines from making efforts beyond any desired limit, which can always be fixed by adjusting the counterweight w. See *Annales des Arts*, tom. xix. p. 190.

SECT. VI. *Methods of Locking and Unlocking Machinery.*

In different parts of this work we have already had occasion to describe several contrivances for this purpose.

One of them is represented between L and N, Plate LIII. Fig. 1. and described in the article BARLEY-MILL.

Another contrivance of the same kind is represented in Plate LV. Fig. 1. at FGHI, and described in the article BLEACHING.

Another contrivance of a very ingenious nature is represented in Plate CCCXXI. Figs. 5, 6, 7, 8, and described in the article HYDRODYNAMICS.

A fourth contrivance, invented by Mr. Brunelle, where the locking is produced merely by friction, is represented in Plate LVIII. Fig. 1. by PNL, which is described in the article BLOCK-MACHINERY.

SECT. VII. *Berthelot's method of converting a reciprocating into a rotatory Motion.*

This mechanism, which is represented in Plate

CCCLXX. Fig. 11. consists of two small wheels, A and B, which turn freely upon the axis MM, but only in one direction, in consequence of a ratchet wheel and click placed on the outer side of one wheel, and on the inner side of the other. Two cords, XX and YY, pass round the circumferences of the two wheels, and are fixed to a moveable frame GGGG. When this frame is drawn towards the right, one of the wheels A not being able to turn about its axis, a rotatory motion is communicated through it to the axis $m\ m$, while the other moves freely about $m\ m$. When the frame GG is pushed backwards, the wheel being no longer detained by the click and ratchet wheel, moves freely about $m\ m$, but the other being now prevented from turning by its click, gives motion to the axis $m\ m$, and in the same direction as that which it formerly received from the other wheel. Hence the axis $m\ m$ will receive a continuous rotatory motion from the alternate motion of the frame G G, See Borgni's *Essai*, &c. p. 370.

SECT. VIII. *Description of a Pulley with a variable diameter.*

We have already described, in another part of this article, the principle of an expanding crane, the expansion being produced by the rotatory motion of a plate. The same method is applicable to the pulley.

The same effect may be produced in a different way, by means of a wheel and pinions. Let $a\ a\ a$, Figs. 12. 13. Plate CCCLXX. be the parts which are to form the circumference of a pulley. Each of these arms or radii, has a piece of wood at right angles to it, which passes through a groove cut in a permanent radius, and has a female screw in it, through which the screw b passes. The ends of this screw are pivots, and the one next the centre carries a pinion d. It is evident, that if all these pinions are driven in one direction by a wheel, the parts a, a, a, &c. will recede from the centre, and will form an expanded circumference, while they will approach to the centre if the wheel turns in an opposite direction. See Borgni's *Essai*, &c. p. 374.

SECT. IX. *Bonesnel's Contrivance for Coiling Ropes round Drums from returning Pulleys.*

This very useful and simple contrivance is shown in Plate CCCLXXI. Fig. 1. where A B is the cylinder or drum round which ropes are to be coiled, that pass over the return pulleys P, P′. It is obvious, that if these pulleys were absolutely fixed, the rope would coil up in a heap opposite to the pulleys P, P′. In order to prevent this, M. Bonesnel fixes the pulleys to arms which move round a centre at M and N, Fig. 1, so that the pulley yields to the rope, and allows it to wind itself more easily and equably round the drum.

SECT. X. *Method of producing a continuous Motion by means of Weights.*

Weights are now in frequent use for producing the various changes of scenery which are requisite in theatrical representations, and also in the movements of automaton figures. Those which are used in theatres have commonly the form shown in Plate CCCLXXI. Fig. 2. where $a\ b$ is a rod of iron terminated below by a small plate b, and in the upper part by a jointed handle c. Several cylindrical weights, 1, 2, 3, 4, 5, are placed on upon another, and having a cut from their circumference to their centre, of the same width as the rod $a\ b$, they can be taken off and put on at pleasure, so as to make the compound weight more or less heavy.

Three different methods of using these weights are shown in plate CCCLXXI. The method of raising the curtains, &c. &c. is shown in Fig. 3. where a is the weight, b a small wheel and mill moved by men, by means of which the weight is raised; AA the curtain to be raised; B b the drum, formed of two concentric parts B and b. The cords 1, 2, 3, 4, 5, which support the curtain, are rolled upon the part b, and a large rope, $m\ n$, coiled round the other part, passes over the pulley p, and terminates in a weight, to the handle of which it is attached. It is easy to see, that if this weight is left to itself, it will cause the cylinder B b to turn; the cords 1, 2, 3, &c. will coil round the drum b, and the curtain will rise with great rapidity. Another cord, $l\ l\ l$, sets out from the same drum B b, and passing over the pulleys r, r, serves to retain the curtain when it is raised, and to moderate its descent when it falls. This cord is tied to the hook x.

Fig. 4. Plate CCCLXXI. shows the method of advancing the frames by means of weights. The frames A, A, rest upon rollers at m and m, $a\ a$ is the floor of the stage; $n\ n$ a lower floor upon which the rollers move; p the weight; $l\ l\ l$ the cord which passes over the pulley g, and coils round the drum B b. The two ropes $x\ x$ and $y\ y$ are coiled at the same time round the part b of the drum. These cords pass over the pulleys 3 and 4, and are attached to the frames $m\ m$, which they drag along with them when the weight descends. The retaining rope $r\ r$ is tied to the hook f.

Fig. 5. Plate CCCLXXI. represents the method of making an actor rise across the stage. The actor to be raised is attached to the bar $a\ a$, which is supported by two cords, 1, 2, which pass over the pulleys 3 and 4, adapted to a moveable frame $b\ b$. The end of the cords 1 and 2 is attached to a fixed point c. The frame $b\ b$ is suspended by a horizontal cord $x\ x$, along which it can move freely. Another horizontal cord $y\ y$, is attached at one end to the frame $b\ b$, and at the other end to a weight p. The wheel and axle f is used to raise this weight, which in its descent carries along with it the frame $b\ b$, which describes the path traced by the cord $x\ x$. At the same time the cords 1 and 2, by their lengthening and shortening, cause the bar $a\ a$ to describe the path marked by the curve-line $z\ z$. See Borgni's *Essai*, &c. p. 185, 186.

SECT. XI. *Camus's Pile Engine.*

This engine is represented in Plate CCCLXXI. Fig. 6. and was intended for the purpose of driving piles for the foundations of houses, piers, bridges, &c. The weight A, which is raised for the purpose of falling by its own weight, and driving the pile R into the ground, is attached to a rope which passes over the pulleys B, C, and is coiled round the vertical drum D, and fixed to it at one end. A capstane, G, with spokes or handles, M, N, O, P, is fixed upon the same axis, and has its drum G of the same diameter as D. The drum D should be encircled with iron, and ought to have two or more projecting pins of iron attached to the circle EF. To the capstane G is fixed, by means of a hook, the lever HI, which has a hook or claw, F, which advances upon the drum D. This lever can descend by the weight of its extremity I, and permit itself to be raised by means of the spring L. This engine is wrought by several men working at the capstane bars, M, N, O, P, by which the capstane G, and the drum D, attached to the capstane by the lever FI, applied to one of the pins E. The rope is then coiled round the drum, and the weight A raised to the required height. When this is done, the man who happens to be placed at N, presses down the end I, of the lever FI, relieves the claw F from the pin which held it and permits the drum D to obey the force of the weight A acting upon it by the rope. The weight therefore descends, and carrying the rope along with it, it strikes the pile upon the head. The lever now pressed back by the spring L, and meeting another pin, it carries along with it the drum, and coils up the rope, and raises the weight as before. See *Machines Approuvées*, Tom III No. 140.

Sect. XII. *Description of another Pile Engine.*

In Plate CCCLXXI. Fig. 7. we have represented another form of the pile engine, in which $p\,q$ is an iron axis, which has a continuous circular motion, either by means of men, horses, wind, or any other mechanical agent. This axis passes through two drums, A B, which are not fixed to it, but have the power of revolving upon it. The lower drum A rests upon a plank, and has its upper end furnished with two irregular surfaces like the threads of a screw, the one interior, and the other exterior, and each going once round the circumference. These surfaces are so formed, that their origin a and a', as well as their termination, are at the opposite extremities of the same diameter. The drum A is also furnished with a ratchet wheel, $r\,r$, and a click s, (seen separately in Plate CCCLXXI. Fig. 8.) which prevents it from turning in the direction of the first mover.

The upper drum, B, is made hollow within, and carries two vertical rods, m, n, with rollers at their lower extremities. This drum is supported in a horizontal position, by means of these rollers, upon the inclined planes of the drum A. The drum B carries also a very strong bar of iron t, reaching to the same height as its upper surface, and the convex surface of the drum is cut into grooves for receiving the rope attached to the weight M. When the rollers, which terminate the rods m, n, are at the origin of the inclined planes, the drum B is at its lowest point; and if we cause it to turn in the direction $c\,b\,a$, contrary to that of the first mover, the rollers will meet the heads of the inclined planes, and force the drum A to turn also. If B, however, turns in the opposite direction, A will remain immoveable, being prevented from turning by the action of the click s upon the ratchet wheel, and B will rise vertically through the height of the inclined planes. To the iron axis $p\,q$ is fixed a cross piece $i\,i$, placed so as to touch almost the upper part of the cavity of the drum B, when it is at its lowest point.

Let us now suppose that the drum B (Plate CCCLXXI. Fig. 7.) is at its lowest point, the rollers being at the origin of the inclined planes; that the bar $i\,i$ is in contact with and ready to act upon the point t; that the weight M is resting upon the head of the pile, and that the rope $d\,d$ is stretched. Then the axis $p\,q$ being put in motion, the drum B will be turned round, coiling the rope round it, and consequently raising the weight, while the drum itself moves; and having come to such a height that the bar t escapes from the cross piece $i\,i$. When this happens, the drum B is disengaged from the axis $p\,q$, and is allowed to obey the action of the weight M, which descends rapidly, and strikes the head of the pile. The height through which the weight M falls is obviously equal to the circumference of the drum B, since the rollers had performed only one revolution on the inclined planes. If we suppose the machinery brought back to its primitive state, when M is resting upon the pile, and if we turn the lower drum A through one semi circumference, in a direction opposite to that of the first mover, then it is manifest that the weight M will fall after the drum B has performed only one half of a revolution, and consequently the height through which the weight has fallen is only one half of the circumference of B. By this contrivance we have it in our power to diminish without limit the extent of the arch of rotation of the drum, and consequently the height of descent of the weight M, which is always equal to that arch. See Lanz and Betancourt's *Essai*, &c. p. 74.

Sect. XIII. *Vauloue's Pile Engine.*

This engine, which is represented in Plate CCCLXXI. Fig. 9 10. was used for driving the piles of Westminster bridge, and, being placed upon a barge, was easily conveyed to any place.

On the great upright shaft A are placed the great wheel B and drum C, which are moved by horses yoked to the bars S, S. The wheel B turns the trundle X, on the top of whose axis is the fly O, which serves to regulate the motion, and also to act against the horses, and keep them from falling when the heavy ram Q is discharged, to drive the pile P down into the mud in the bottom of the river. The drum C is loose upon the shaft A, but is locked to the wheel B by the bolt Y. On this drum the great rope HH is wound, one end of the rope being fixed to the drum, and the other to the follower G, to which it is conveyed over the pulleys I and K. In the follower G is contained the tongs F, (see Plate CCCLXXI. Fig. 11.) that take hold of the ram Q by the staple R, for drawing it up. D is a spiral or fusee fixed to the drum, on which is wound the small rope T that goes over the pulley U under the pulley V, and is fastened to the top of the frame at 7. To the pulley block V is hung the counterpoise W, which hinders the follower from accelerating as it goes down to take hold of the ram; for, as the follower tends to acquire velocity in its descent, the line T winds downward upon the fusee on a larger and larger radius, by which means the counterpoise W acts stronger and stronger against it, and so allows it to come down with only a moderate and uniform velocity. The bolt X locks the drum to the next wheel, being pushed upward by the small lever 2, which goes through a mortice in the shaft A, turns upon a pin in the bar 3 fixed to the great wheel B, and has a weight 4, which always tends to push up the bolt Y through the wheel into the drum. L is the great lever turning on the axis m, and resting upon the forcing bar 5, 5, which goes down through a hollow in the shaft A, and bears up the little lever 2.

As the horses go round, the great rope H (Plate CCCLXXI. Fig. 9 10.) is wound about the drum C, and the ram Q is drawn up by the tongs F in the follower G, until the tongs come between the inclined planes E which, by shutting the tongs at the top, opens them at the foot, and discharges the ram, which falls down between the guides *b*, *b*, upon the pile P, and drives it by a few strokes as far into the mud as it can go; after which the top part is sawed off close to the mud by an engine for that purpose. Immediately after the ram is discharged, the piece 6 upon the follower G takes hold of the ropes *a*, *a*, which raise the end of the lever L, and cause its end N to descend, and press down the forcing bar 5 upon the little lever 2, which, by pulling down the bolt Y, unlocks the drum C from the great wheel B, and then the follower, being at liberty, comes down by its own weight to the ram, and the lower ends of the tongs slip over the staple R, and the weight of their heads causes them to fall outwards, and shut upon it; then the weight 4 pushes up the bolt Y into the drum, which locks it to the great wheel, and thus the ram is drawn up as before.

As the follower comes down, it causes the drum to turn backward, and unwinds the rope from it, while the horses, great wheel, trundle and fly, go on with an uninterrupted motion, being resisted by the force accumulated in the revolving fly; and as the drum is turning backward, the counterpoise W is drawn up, and its rope T wound upon the spiral fusee D.

There are several holes in the under side of the drum, and the bolt Y always takes the first one that it finds, when the drum stops by the falling of the follower upon the ram; until which stoppage the bolt has not time to slip into any of the holes.

The weight of the ram was one ton, and the guides *b*, *b*, between which it was drawn up and let fall, were 30 feet high. The great wheel had 100 cogs, the trundle 10 staves; and the fly made 10 revolutions for one of the great wheel. See Ferguson's *Lectures*, vol. i. p. 118, and Belidor's *Architect. Hydraul.* vol. i. p. 107.

Sect. XIV. *Bunce's Pile Engine.*

The pile engine, invented by Mr. S. Bunce, and represented in Plate CCCLXXI. Fig. 12. raises the ram by a continuous uninterrupted motion, as in Vauloue's engine. It is more simple, and therefors less expensive, and less liable to be put out of order. In the front and side view of it, AA is a double endless rope or chain, formed together by cross pieces of iron, B, B, B, and which, during their motion over the wheels CD, fall into corresponding cross grooves cut diametrically opposite on the periphery of the wheels. A strong wooden frame, moveable round the axis H, is represented as seen sideways by FHK, and at the top of it is fixed the wheel D, over which the rope AA passes. This wheel D is capable of moving from the position F into that of G by the motion of the frame DHK round H, and it is retained in the position F by the weight I fixed at K. The iron ram L, (Fig. 13.) shown in a separate figure, is suspended on the cross pieces of iron B, B, B, &c. by the hook M. A cylindrical piece of wood N is suspended at O from the cross piece or lever OQ, which is at right angles to the vertical or straight part of the hook M; and by the descent of this piece N along the bar which unites the hook with the ram L, the lever OQ is brought into a horizontal position.

When the ram is suspended by the hook M (Plate CCCLXXI. Fig. 12.) upon one of the cross pieces of iron B, its weight, acting at the end F of the lever FI, pulls the wheel F into the position at G; and when the rope is turned round by a man working at the crane S, the ram runs between the guides in a perpendicular direction; and when it has reached R, near the top of the machine, the projecting end Q of the lever OQ strikes the cross piece of wood at R, in consequence of which the end Q is pressed down, as seen in the small figure, and the hook M raised from the cross piece of iron B, upon which it hung. The ram consequently falls upon the head of the pile. The descent of the weight N having pulled down the other end OM of the lever OQ, it presses OQ into a horizontal position, and the hook M into its right situation, the ram remains upon the head of the pile, ready to be lifted a second time. When the lever FI has been freed from the weight of the ram, the counterweight at I forces back the wheel D from the position G to the position F; and as the man at S continues to turn the crane, one of the cross pieces B seizes the ram by its hook at M, the consequence of which is, that the extremity D of the lever DI now preponderates, D descends to G, and the ram raised to R is detached, and falls as before. The piece N is made of wood, in order that the hook M may not regain its proper position till after the ram has reached the head of the pile, for if it did, the hook would lay hold of one of the cross pieces B in its descent.

We shall now conclude this article with a tabular arrangement of machines, principally with the view of classifying the references to the principal machines described in this work.

GENERAL ARRANGEMENT OF MACHINES.

CLASS I.

MACHINES FOR OVERCOMING INERTIA.

I. *Machines for Raising Weights.*

1. Bramah's Hydrostatic Crane	Plate CCXV.	Figs. 1—3.	See Crane.
2. White's Crane		Fig. 9.	
3. Gilpin's Crane		Figs. 5—8.	
4. Keir's Moveable Crane		Fig. 9.	
5. Hardy's Lowering Cylinder		Figs. 10, 11.	
6. Cast Iron Cranes of various kinds	Plate CCXVI.		
7. Lloyd's and Ostell's Cranes	Plate CCXVII.	Figs. 1, 2, 3.	
8. Cranes used in constructing the breakwater of Aberdeen		Figs. 4—8.	

9.	Dredging Machines	Plate CCXXXIX.		See Dredging Machine.
10.	Hand Jack for raising Weights	Plate CCXCIX.	Fig. 6.	See Jack.
11.	Screw Jacks for raising Weights		Figs. 7, 8, 9.	
12.	Roasting Jacks of various kinds		Figs. 3, 4, 5.	
13.	Fire Escapes. See Fire Escapes.			
14.	Camel for raising Weights	Plate CIX.	Figs. 1, 2, 3.	See Camel.
15.	Machinery used in Theatres	Plate CCCLXXI.	Fig. 2—5.	See Mechanics.

II. *Machines for transporting Weights on Land.*

1.	Wheel Carriages. See Agriculture, Chap. VI. Sect. IV.		
2.	Carriages	Plates CXXXI. CXCVIII. and CXCI.	See Coach-making & Carriage.
3.	Coaches		
4.	Steam Waggons. See Steam Waggons.		

III. *Machines for Raising Water.*

1.	Machine for emptying the foundation of Neuilly Bridge	Plate XCV.		See Bridge.
2.	Archimedes's Screw	Plate CCCXXII.		See Hydrodynamics.
3.	Zurich Machine	Plate CCCXXIII.	Figs. 1, 2.	
4.	Gaining and Losing Buckets		Fig. 10.	
5.	Scoop Wheel	Plate CCCXXIV.	Fig. 1.	
6.	Persian Wheel		Fig. 2.	
7.	Chain Pump		Figs. 4, 5.	
8.	Hair Rope Machine		Fig. 6.	
9.	Whitehurst's Engine		Fig. 7.	
10.	Hydraulic Ram		Figs. 8, 9, 10.	
11.	Chemnitz Fountain		Fig. 12.	

IV. *Blowing Machines.*

1.	Blowing Engine	Plate LXIII.	See Blowing Engine.
2.	Blow Pipes	Plate LXII.	See Blow Pipe.

V. *Machinery for ascending and descending in Fluids.*

1.	Klingert's Diving Apparatus	Plate CCXXXI.	Figs. 1, 2, 3.	See Diving Apparatus.
2.	Rowe's Diving Chest		Fig. 4.	
3.	Diving Tongs		Fig. 7.	
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VI. *Machines for Navigation.*

1.	Boats.	See the article Boat.
2.	Ships.	See Shipbuilding.
3.	Track Boats.	See Navigation, *Inland*.
4.	Steam Boats.	See Steam Boats.

CLASS II.

MACHINES FOR OVERCOMING COHESION.

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3.	Veitch's Plough		Fig. 11.	
4.	Plough for cleaning Turnips		Fig. 10.	

II. *Drilling Machines.*

1.	Bailey's Drilling Machines	Plate VII.	Figs. 1, 2, 3, 6.

III. *Reaping Machines.*

1.	Gladstone's Reaping Machine	Plate VIII.	Figs. 1, 2, 3.

IV. *Thrashing Machines.*

1.	Meikle's Thrashing Machine	Plate IX.	Fig. 1.

V. *Mills.*

1. Barley Mill	Plate LIII.	Fig. 1.	See Barley Mill
VI. *Block Machinery.* Brunell's.	Plate LVII. LVIII. LIX. LX. LXI.		See Block Machinery.
VII. *Boring Machines.*	Plate LXIII.		
VIII. *Machinery used in Button-making*	Plate CVII.		See Button-making.
IX. *Card Wire Machine*	Plate CXI.		See Card.
X. *Chaff-cutting Machines*	Plate CXXXV.		See Chaff-cutter.

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1. Wash Stocks used in Bleaching	Plate LV.	Figs. 6, 7.	See Bleaching.
2. Dash Wheels used in Bleaching		Figs. 1, 2, 3.	
3. Parkinson's Squeezers		Fig. 4, 5.	
4. Lawrie's Bleaching Apparatus	Plate LVI.	Fig. 2.	
5. Goodwynne's Apparatus for washing Casks	Plate LXXVIII.	Fig. 7.	See Brewing.

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1. Roller Gin for separating the Seeds	Plate CCXII.	Fig. 1.	See Cotton.
2. Saw Gin		Fig. 2.	
3. Centrifugal Cotton Picker		Fig. 3.	
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XIII. *Grinding Machines.*

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2. Grinding Machines by Pestles and Mortars		Figs. 3, 4, 5.	
3. Eckhardt's Rolling Stone		Fig. 6.	
4. Rawlinson's Grinding Machine		Fig. 2.	
5. Grinding Machines with Cannon Balls		Figs. 7, 8.	
6. Terry's Grinding Machine		Fig. 9.	

XIV. *Machines for Turning.*

1. Machine for Turning Buttons See the article Turning.	Plate CVII.	Fig. 1.	See Button Making.

XV. *Machines which act by Compression.*

1. Bramah's Hydrostatic Press	Plate CCXV.	Fig. 1, and	See Crane, Calender, and Hydrodynamics.
	Plate CVIII.	Fig. 6.	
2. Printing Presses 3. Copperplate Presses } See Presses.			
4. Bramah's Bank Note Press	Plate LXXVI.		See Bramah.
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7. Glazing Table		Figs. 2, 3.	
8. Five bowl Calender		Fig. 4.	
9. Glazing Calender		Fig. 5.	
10. Muslin Calender		Fig. 7.	
11. Press for Bandana Handkerchiefs	Plate LII.	Fig. 4.	See Bandana.
12. Pressing Vice for Horn Buttons	Plate CVII.	Fig. 7.	See Button-making.
13. Pollzaffell and Deyerlin's Machine for pressing Horn	Plate CCXCIX.	Figs. 1, 2.	See Horn Pressing.
14. Bramah's Hydrostatic Jack	Plate CCXCIX.	Fig. 10.	See Jack.

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XVII. *Pile Engines.*

1. Bunce's Pile Engine	Plate CCCLXXI.	Fig. 12.	See Mechanics.
2. Vauloue's Pile Engine		Fig. 9—11	
3. Camus's Pile Engine		Fig. 6.	
4. Another Pile Engine,		Fig. 7.	

CLASS III.

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1.	Common Draw Loom,	Plate CXXX.	Fig. 1, 2, 3	
2.	Common Damask Loom,		Fig. 4. 5.	
3.	Duncan's Automatic Carpet Draw Loom,		Fig. 6. 7.	
4.	Duncan's Tambouring Machinery	Plate CXXXVI.—CXXXVII.		See Chain-Work
5.	Machines for working Stockings,	Plate CXXXVIII.		
6.	Machine for Weaving Nets,	Plate CXXXIX.		
7.	Looms,	Plate CXCIV.		
8.	Wiper Loom,	Plate CXCV.	Fig. 1.	See Cloth Manufacture.
9.	Crank Loom,		Fig. 2.	
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11.	Stockport Dressing Machine,		Fig. 9.	
12.	Barrowfield Dressing Machine		Fig. 10.	
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15.	Arkwright's Spinning Machinery,	Plate CCXIV.		
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17.	Loom for Lappets,	Plate CCXX.	Fig. 4, 5.	
18.	Draw Loom for Damask Tweelings,	Plate CCXXVII.	Fig. 1.	
19.	Machine for making Hats,	Plate CCLXXXVIII.	Fig. 7, 8.	See Hat-making.
20.	Brocade Loom,	Plate CIV.		See Brocade.

II. *Machine for combining Materials in Brewing.*

.	Dickson's Mash Tun,	Plate LXXVIII.	Figs. 1, 2, 3, 4.	See Brewing.

CLASS IV.

MACHINES FOR MEASURING FORCES.

I. *Anemometers.*

1.	Hooke's	Plate XXVIII.	Fig. 1.	See Anemometer.
2.	Wolfius's		Fig. 2, 3, 4	
3.	Martin's		Fig. 5.	
4.	Ons-en-Bray's.			
5.	Bouguer's	Plate XXVIII.	Fig. 6.	
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7.	Demenge's Spiral one	Plate XXIX.	Figs. 1, 2, 3, 4, 5, 6.	
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10.	Pickering's		Fig. 7.	
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17.	Dr. Brewster's Hydrostatical one		Fig. 12.	
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20.	Bouvet's		Fig. 11.	

II. *Torsion Machines.*

1.	Cavendish's Contrivance for measuring the attraction of Gravitation	Plate XLIX.	Fig. 7.	See Attraction of Mountains.
2.	Coulomb's Torsion Balances	Plate CCXLIV. CCXLV.	Fig. 7. Figs. 1, 2.	See Electricity, Magnetism, and Mechanics.

III. *Balances and Steelyards.*

1. Troughton's Balance	Plate LI.	Fig. 1	See BALANCE.
2. Troughton's Assay Balance		Fig. 9.	
3. Adie's	Plate LII.	Fig. 1.	
4. Roman Steelyard	Plate CCCLXI.	Fig. 8.	See MECHANICS.
5. Steelyard		Fig. 9.	

IV. *Barometers.* See BAROMETER.

V. *Thermometers.* See THERMOMETER.

VI. *Hygrometers.* See HYGROMETRY.

VII. *Machines for Measuring the Elasticity and Strength of Materials*

1. Gravesende's Apparatus for measuring Elasticities,	Plate CCCLXIX.	Fig. 8.	
2. Coulomb's Apparatus for measuring the Flexion of Plates,	Plate CCCLXIV.	Fig. 7.	
3. Dr. Brewster's Teinometer	Plate CCCLXIX.	Fig. 9—12.	
4. Apparatus for measuring the strength of Materials,		Fig. 7.	See MECHANICS.

VIII. *Dynamometers for measuring the Force of Men, Animals, and other agents.*

1. Graham's Dynamometer	Plate CCLXII.	Fig. 1.	See DYNAMOMETER.
2. Regnier's Dynamometer		Fig. 2—11.	
3. Brewster's Dynamometer		Fig. 12.	
4. Hachette's Dynamometrical Machine	Plate CCCLXX.	Fig. 3, 4.	See MECHANICS.
5. Smeaton's Apparatus for experiments on Rotatory Motion	Plate CCCLXIX.	Fig. 1.	
6. Smeaton's Apparatus for experiments on Windmill Sails		Fig. 2.	
IX. *Ballistic Pendulum for measuring the Force of Projectiles,*	Plate CCLXXXIV.	Fig. 11.	See GUNNERY.

X. *Machines for Measuring the force of Running Water.*

1. Hydraulic Quadrant	Plate CCCXXIII.	Fig. 4.	See HYDRODYNAMICS.

CLASS V.

MACHINES FOR MEASURING AND DIVIDING SPACE.

I. *Quadrants.*

1. Astronomical Quadrant	Plate XLVI.	Fig. 6.	See ASTRONOMY.
2. Troughton's Quadrant	Plate XLV.		

See also the Article QUADRANT.

II. *Circles.* See ASTRONOMY.

1. Troughton's Astronomical Circle	Plate XLVI.		
2. Mayer's Circle	Plate CXLIV.	Fig. 1 and 2.	See CIRCLE.
3. Borda's Circle		Figs. 3 and 4.	
4. Troughton's Reflecting Circle,	Plate CXLV.		
5. Troughton's Portable Altitude and Azimuth Circle,	Plate CXLVI.		
10. Troughton's Repeating Circle,	Plate CXLVII.		

III. *Theodolites.* See SURVEYING.

IV. *Levels.* See SURVEYING.

V. *Micrometers.*

1. Troughton's Wire Micrometer,	Plate XLVIII.	Figs. 1, 2, 3.	See ASTRONOMY.
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4. Brewster's Divided Object Glass Micrometer,			
5. ———— Luminous Image Micrometer,			
6. ———— Angular Wire Micrometer,			
7. ———— Position Image Micrometer,			
8. Herschel's Lucid Disc Micrometer,			See MICROMETER.
9. Ramsden's Divided Eye-Piece Micrometer,			
10. Ramsden's Divided Mirror-Piece Micrometer,			
11. Maskelyne's Prismatic Micrometer,			
12. Rochon's Doubly Refracting Micrometer,			
13 Cavallo's Mother-of-Pearl Micrometer,			
14 Brewster's Mother-of-Pearl Micrometer,			
15. Herschel's Lamp Micrometer,			
16. Wollaston's Micrometer,			

VI. *Goniometers.*

1. Haüy's Goniometer,	Plate CCXXIII.	Fig. 34.	See Crystallography, and Goniometer.
2. Wollaston's Reflecting Goniometer,	Plate CCXXIV.	Fig. 1.	
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VII. *Dividing Machines.*

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2. Troughton's Dividing Engine,	Plate CCLXXIX.	
3. Ramsden's Straight line Dividing Engine,	Plate CCLXXX, CCLXXXI, CCCLXXXII.	
4. Farey's Dividing Instrument,	Plate CCXXXVI. Fig. 21.	See Drawing Instruments.

VIII. *Odometers.* See Odometer.

IX. *Drawing and Copying Instruments.*

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2. Parallel Ruler,		Fig. 12.	
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2. Leach's Craniometer,		Fig. 7.	

CLASS VI.

MACHINES FOR MEASURING TIME.

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MECKLENBURG, a town of the duchy of the same name. It has been called by some historians Megapolis, on account of its great extent. It is the ancient capital of the Obotrite princes, and was then a flourishing town, but it was destroyed in 1164. It was rebuilt in the 12th century, but is now little better than a village. It formerly contained three convents, and a bishopric was founded in 1058. It is two miles south of Weimar.

MECKLENBURG, Duchy of, is a principality including the duchies of Schwerin and Gustro. It is bounded on the north by the Baltic, on the east by Pomerania, on the south by Brandenburg, and on the west by the territory of Lubeck and the principality of Luneburg. The two duchies are divided into three circles, and in both duchies, (exclusive of Rostock,) there are 45 great and small cities. All the towns have grammar schools, and there is an university at Rostock. The inhabitants of both duchies are Lutherans, but the Calvinists and Roman Catholics are permitted the private exercise of their worship. The duchy of Schwerin contains 7000 square miles, 290,000 inhabitants, and furnishes a revenue of 1,800,000 guilders. The other duchy contains 800 square miles, 66,000 inhabitants, and has a revenue of 525,000 guilders.

Of the house of Mecklenburgh, there are two lines still subsisting, viz. that of Schwerin and that of Strelitz: the Schwerin line commenced in Duke Frederic William, and the Strelitz line in Duke Adolphus Frederic II. The present king of Great Britain married the second sister of the latter sovereign. The states, which are formed of the nobility and the burgesses, are assembled annually, to regulate the taxation, &c. &c. The Duchy of Schwerin appoints four provincial counsellors, and Gustro sends the same.

The soil of this country, according to some accounts, is very unproductive; but if we are to credit the description of Cluvier and of Frank, it is on the contrary extremely fertile, producing, even in the most sandy land, excellent rye; and, where it is well cultivated, it yields barley and wheat at the rate of five or even six or eight fold.

It has only one harbour on the Baltic, namely, Rostock, formed by the mouth of the river Warne, but a number of Mecklenburg vessels are employed in the trade of other parts of the Baltic. There is very little trade. From the improvements in the breed of sheep during some years back, government has established a wool fair, which is held in the town of New Brandenburg. The country is pleasantly diversified with useful woods and lakes, which abound with fish, particularly cray and eels. There are good fruit trees, and the pasture is excellent; grazing is carried on to a great extent, and some thousands of cattle are annually exported.

The principal rivers are the Elbe, the Star, the Reikenitz, and the Uavel. The exports are grain, flax, hemp, hops, honey, cattle, butter, cheese, fruits, feathers, dried geese, tallow, linseed, wool, and timber. The imports are trifling, with the exception of salt, which is in demand; the rest are coffee, rum, (not Jamaica,) refined sugars, and some tobacco. The only manufactures are wool and tobacco. It contains 300,000 inhabitants, and is about 4800 miles in extent.

The principal towns are Rostock, Schwerin, and Weimar. Rostock is a sea-port town. It contains 13,736 inhabitants, three churches, and an university, which was founded in 1419. In 1437, in consequence of a misunderstanding having arisen between the Dukes and the town, the university was removed to Lubeck, but restored again in 1492. The Dukes nominate and pay 15 professors, and the town nine. The senate of the academy consists of nine ducal professors, and nine appointed by the magistrates. The Dukes annually contribute the sum of 3000 florins, and the town 500, towards the salaries of the professors. This town has the right of coining copper, and silver and gold, and it therefore has a mint, 25 miles north-east of Weimar. The town of Schwerin is situated on a beautiful lake, called the Schwerin Sea, which almost surrounds it. The town is nearly square, and is divided into three parts, viz. Schwerin, the New Town, and the Moor. The Duke's palace, which is a fortified building, is situated on an island in the lake, and contains a valuable collection of paintings. In 1759 this city was bombarded and plundered of its archives and cannon by the King of Prussia, who taxed the duchy at 7000 men, and a million of crowns. Its population is 9801. Thirty-four miles east south east of Lubeck Weimar is situated, in the Bay of the Baltic. It has a good harbour, and is large and well fortified, and defended by a citadel. It contains 6254 inhabitants, six churches, and a grammar school. The court of justice consists of a president, a vice-president, and four assessors. See Pinkerton's *Geography*; Rordanz *European Commerce*; *Dictionnaire Geographique*, & &c.

MECRAN. See MEKRAN.

MEDALS. See NUMISMATOLOGY.

MEDIA, or MEDENA, is the ancient name of an extensive empire in Asia, which, according to Ptolemy, was bounded on the north by part of the Caspian Sea, on the south by Persia, Susiana, and Assyria, on the east by Parthia and Hyrcania, and on the west by Armenia Major. It was formerly divided into Media Magna, and Media Atropatra, or Atropatene; and it now forms part of the province of Ghilau in Persia.

The Medes are said to have been descended from Madai, the third son of Japhet. They were first brought under the Assyrian yoke by Pul, who was succeeded by his son Tiglath-Pileser, in the year 740, B. C. About the end of the reign of Sennacherib, in 710, B. C. they fell into a state of anarchy, while attempting to throw off the Assyrian yoke; in consequence of which, Esar-Haddon, the successor of Sennacherib, reduced almost all Media under subjection. Dejoces, who had excited the revolt against Sennacherib, being chosen king about 699, B. C. united the scattered tribes of the Medians, built Ecbatana as the capital of his empire; and having enacted various laws, he applied himself to the civilization of his subjects. His mind, however, was soon occupied with more ambitious objects; and he resolved to invade Assyria, for the purpose of adding to his dominions. Nebuchadnezzar, the Assyrian king, met him in the plain of Ragua, and a battle ensued, in which the Medes were completely routed, and Dejoces slain, after a reign of 53 years. His son Phraortes, who succeeded him in 647, was animated with the same ambition as his father, and is said by Herodotus to have invaded and conquered Persia. He subdued, however, many neighbouring nations; and having invaded Assyria, and taken possession of a great part of it, he laid siege to Nineveh, where he perished, with the greater part of his army, after a reign of 22 years. His son Cyaxares I. succeeded him in 625. He laid siege to Nineveh; but having learned that his own kingdom was threatened by an army of Scythians, he returned, and was completely routed in the battle which ensued. Having found it impracticable to overpower the Scythians by force, Cyaxares tried the effect of deceit. He invited them to a general feast, which was prepared in every family; and each host having intoxicated his guest, afterwards massacred him, and in this way relieved the kingdom from the bondage of the Scythians.

The Medians now retook the territories which they had lost, and were soon afterwards engaged in a war with the Lydians. Cyaxares now entered into an alliance with Nebuchadnezzar, king of Babylon; and having been joined by his forces, they took the city of Nineveh in 606, B. C. and levelled it with the ground. Hence arose the united empire of the Medes and Babylonians, which attained a great extent from the successes of Nebuchadnezzar and Cyaxares. Cyaxares died in the 40th year of his reign, and was succeeded by his son Astyages, or Ahasuerus, who, after a reign of 35 years, was succeeded, in 560, by his son Cyaxares II. the uncle of Cyrus. Under the reign of Cyaxares and Cyrus, Babylon was taken and destroyed. Upon the death of Cyaxares, Cyrus obtained possession of the empire, but transferred the seat of it to Persia. See the articles ASSYRIA, BABYLON, CYRUS, and PERSIA.

MEDICI. See ITALY, and LEO X.

MEDICINE.

Medicine is the science which treats of the means of preventing disease, or of removing it when actually present. The term is immediately derived from the Latin word *medicina*, and, perhaps, more remotely, from the Greek verb μεδω or μεδεω. We shall divide the article into five parts: 1*st*, The History of Medicine; 2*d*, Pathology, or the general doctrines of disease; 3*d*, Therapeutics, or the general doctrines of the action of remedies; 4*th*, Nosology, or the arrangement of diseases; and 5*th*, The Practice of Medicine, or the description of particular diseases, with their treatment.

Part I.—THE HISTORY OF MEDICINE.

The history of medicine may be conveniently arranged into five principal periods or eras—the first commencing with the earliest records of knowledge, and continuing to the death of Hippocrates; the second from the death of Hippocrates to that of Galen; the third from the time of Galen, through the dark ages, to the revival of letters; the fourth from the revival of letters to the middle of the 18th century; the fifth from the middle of the 18th century to the present day.

CHAP. I.

The first period, from the earliest records of knowledge to the death of Hippocrates.

Much learned discussion took place, about a century ago, respecting the origin of medicine, and even in our own times, this point has been warmly agitated. Without entering into a minute or critical examination of the different arguments that have been adduced, we may venture to conclude, with tolerable certainty, that in no country could there be any considerable approach to a state of civilization or refinement, in which some attempts would not be made to cultivate the art of medicine. The human frame, in every situation, is subject to the action of noxious causes, which must induce a derangement of its functions; and it is impossible that these evils could have been experienced, in any great degree, without an endeavour to alleviate them. How this original foundation of medical knowledge was obtained, is a point in which we must be guided by conjecture; but we may conceive of many accidental circumstances that would lead to the first efforts. From the effect of particular kinds of food, when taken into the human stomach, or from observing their operation on animals, some notion might be formed of emetics and purgatives, and from the relief which had been incidentally experienced, by the spontaneous evacuation of the stomach and bowels, the idea would present itself, of obtaining the same relief by artificial means.

If we include under the title of medicine, not only that science which is at present so denominated, but likewise extend it to surgery, which was originally the case, we shall be able to trace more satisfactorily the gradual rise and progress of the art. When the body had received an external injury, some means would unavoidably be had recourse to for procuring present relief, or averting the impending danger; attempts would be made to stop the flow of blood, and to screen the part from the air, and from extraneous substances, and thus, partly from the obvious action of the remedies, and partly from their effect on the sensations of the patient, a rude species of surgical practice would be established, not unlike that which exists at this day among the inhabitants of those countries which still remain in their state of original barbarism.

Without therefore gravely inquiring who was the first physician; whether this honour belongs to Adam; whether our first parent derived his supposed skill from a miraculous communication with the Deity, from instinct, or from observation,—we may conclude, that the kind of medicine which we have described above, would be among the earliest acquirements of the human species, and that this knowledge would advance in proportion to the developement of the mind, on other subjects intimately connected with their existence and welfare.

So far we may proceed upon the ground of probable conjecture. And we shall find the above conclusion to be sanctioned by historical testimony; for, from the uncertain light which we derive from the earliest records of remote antiquity, we learn that Egypt, the country which is regarded as the nurse of the arts and sciences, was also the parent of medicine. (Conringii, *Introd.* c. 3. § 2.) We have, however, little positive information upon the subject, except the simple fact, that in Egypt there were persons who made medicine an object of particular attention. How far it was their exclusive occupation is doubtful; whether certain individuals were regularly trained to it, and made it their sole business, as in later times; whether it was attached to the priestly office; or whether particular persons, in various departments of life, acquired superior skill in the cure of diseases, we are not able positively to determine. The most probable supposition, however, is, that the priests were the first physicians; a supposition which is favoured by the scanty records of Egyptian history, and which is with more certainty known to have been the case among the Greeks, who borrowed from the Egyptians many of their institutions. From the account which is incidentally given by Moses of the Egyptian priesthood, it may be concluded that a considerable portion of their learning consisted in the dexterous management of the arts of magic and incantations, and it may be concluded that a large share of their medical skill depended upon the judicious application of their supposed preternatural power to the imagination of their patients. This has, in all countries, been the first step in the art, and it has maintained its influence, in proportion to the ignorance of the individuals upon whom it has been exercised.

Beyond this point it appears in vain to push our inquiries; at least all the information that we can expect to obtain is so blended with fiction, as to become more a subject for philological discussion than for scientific investigation. It is impossible for us to ascertain with certainty the very existence of the semi-fabulous characters, that are regarded, in the mythology of Egypt, as the inventors of the useful arts, and, among others, of medicine; and while it is not yet determined, by the most learned antiquaries, whether Hammon and Thouth, Serapis and Isis, are to be considered as real or poetical personages, it is obviously premature to endeavour to decide what share they had in the discovery or the improvement of medicine.

A fact is mentioned by Herodotus, respecting the state of medicine in Egypt, which he probably learned by his personal acquaintance with the country; but it refers to a condition of society long subsequent to that which we are now considering. He informs us, that particular persons undertook the treatment of particular diseases only, or rather that they took charge of particular parts of the body. (*Euterpe*, § 84.) This state of the art indicates, on the one hand, that the *practice* of medicine must have been an object of considerable attention before such a division of labour could have taken place, while, on the contrary, it demonstrates no less clearly, that the *science* must have been in a very low state; in short, that the only requisites for the practioner were, a degree of manual dexterity, and the possession of certain empirical remedies. This peculiar state of things might, in some measure, depend upon the custom which existed in Egypt, of handing down the same occupation from father to son, through successsive generations, which prevailed universally among the inhabitants, and which, although it may be favourable to the perfection of any particular art, must undoubtedly prove a decisive obstacle to the general improvement of science and the progress of the mental powers.

According to the opinion of the most learned antiquaries, the empire of Babylon, or Assyria, was even more ancient than that of Egypt, and has been supposed to have a prior claim to be considered as the inventor of the arts and sciences. There is reason to believe that one of these countries borrowed its knowledge from the other; and it seems, upon the whole, most probable, that it originated in Assyria. Yet the Assyrians have less direct testimony in their favour; and their knowledge, if they ever possessed it, has left behind fewer memorials than that of the Egyptians. As the inhabitants of Babylon, at a very early period, arrived at a state of comparative civilization and luxury, we might conclude that medicine would receive its appropriate share of attention. The priests of this people, or, as they have been called, the Chaldeans, appear to have been the first body of men who acquired a reputation for their learning; and although, like the Magi of Persia, and the Brachmans of India, their learning consisted principally in the arts of divination and astrology, yet we may suppose that, like the priests of other ancient nations, they would become the depositaries of all the knowledge of the times. Enfield's *Hist. Phil* v. i. p. 25, *et seq.* Bryant's *Anal.* iii. 125.

The state of medicine among the Assyrians in the age of Herodotus, was, however, much less advanced than at the same period in Egypt; for this writer informs us that there were no physicians in Babylon, but that the custom was to carry the patient into some public place, where the passengers, by inquiring into the nature of the disease, might communicate any information which they accidentally possessed, from having experienced in their own persons, or observed in others, the operation of remedies in what appeared to be a similar case. (*Clio*, § 197.) But we must suppose that this kind of casual practice was only had recourse to in internal complaints, or in such as were thought peculiarly obscure; for it is scarcely possible to imagine, that in the common diseases, and especially in wounds or external injuries, a general routine of practice would not be established; for this we observe to be the case even among the most rude savages of North America or of Australasia.

We find, from some passages in the Pentateuch, and especially from the account of leprosy in the book of Leviticus, that the Jews had made, at this early period, a considerable progress in the knowledge of medicine. But for this it is probable that they were principally indebted to their great legislator, Moses, who acquired it during his residence in Egypt. The practice, it would appear, was chiefly confined to the priests, and consisted partly in dietetic regulations, and partly in those circumstances which are calculated to act upon the imagination.

Much controversy has existed respecting the time when the arts began to be cultivated in the eastern parts of Asia; but it may be certainly concluded, that the inhabitants of India were among the first who obtained any considerable degree of civilization. We have reason to believe, that medicine came in for its share of their attention; and it is not improbable, that the knowledge which was afterwards matured in Greece was, in some measure, derived from the Gymnosophists, a class of men who united the character of priest and philosopher, and who were possessed of all the learning of their age and country.

Although Greece was destined to become the favourite seat of the arts and sciences, yet it appears that she had not the honour of giving birth to them, but that they had even made considerable advances in some other countries, while she still remained in her state of original barbarism. It is the general opinion, that Greece received from Egypt its first knowledge of the fine arts, as well as of many of those which are more directly subservient to the purposes of utility. (Bryant, iii. 299.) And there are many circumstances which render it probable, that this was the case with respect to medicine. There is a remarkable resemblance or analogy between the characters and designations of the divinities that were worshipped in those two countries, as being entitled to the honour of the invention of this science. The Isis, Osiris, and Thouth of Egypt, were transferred to Greece, and became converted into Apollo, Minerva, and Orpheus; and the same attributes assigned to them which they possessed on the banks of the Nile; and even when we get into later times, and arrive at something more like authentic history, we find it difficult to determine to which of these districts some of the most celebrated characters are to be referred. The Grecian mythology, not only in its general outline, but in its individual parts, was derived from the Egyptians. The inhabitants of Greece, when they were desirous of acquiring any superior degree of information, had recourse to the priests of Egypt, obtained from them the knowledge of which they were regarded as the sole depositaries, and were initiated into their mysteries. Of this knowledge, medicine, such as it then was, principally composed of charms and incantations, formed an important branch, and became, in the hands of the sacred order, an instrument rather of power and authority, than of benevolence. Herodotus, *Euterpe*, passim.

The Centaur Chiron, who lived in the 13th century before the Christian æra, has obtained the credit of having first initiated the Grecians into the art of medicine. Notwithstanding the cloud of mystery and fable in which his history is involved, we may presume, with some considerable plausibility, that he was a prince or chief of Thessaly, who, in consequence of his being frequently seen on horseback, according to the habits of his countrymen, was conceived to possess a combination of the human with the equine form. How he acquired his medical skill is unknown; but it may be conjectured, that in the state of society to which he belonged, it was considered rather as an accomplishment, which attached to the higher ranks, than as a means of emolument. Accordingly, many of the heroes who accompanied Jason on his expedition to the Euxine, and of those who afterwards joined in the armament against Troy, are famed for their knowledge of medicine, which they are said to have gained from the instruction of Chiron.

Among the pupils of Chiron was Æsculapius, who became still more celebrated than his preceptor, so that after his death he was deified by his countrymen, in gratitude for the services which he bestowed upon them. Many fictions were circulated respecting his birth and parentage, which it is not necessary to notice in this place. By his fabled descent from Apollo, we may understand, either that he possessed a degree of skill which it was supposed could not have been obtained by a mere mortal, or that some one connected with the temple of the god, or assuming his character, was actually his father.

He is said to have been born in Epidaurus,—to have been exposed in his infancy, and accidentally discovered by a shepherd on the mountains, a circumstance which favours the supposition of his illegitimate birth, and to have been afterwards placed under the tuition of Chiron, from whom he acquired so much skill in medicine, as even to restore the dead to life. Having from this circumstance excited the hostility of Pluto, who found himself in danger of being deprived of his consequence and authority, Æsculapius was destroyed by the thunderbolt of Jupiter. Gronovii, *Thes. Græc. Antiq.* vii. 278, *et alibi.*

He left two sons, Machaon and Podalarius, who, as we learn from Homer, accompanied the Grecians to the siege of Troy, and possessed at least a considerable share of their father's medical knowledge. They seem, however, to have attended Agamemnon rather in the capacity of warriors than of physicians, being enumerated among the other chiefs who brought their complement of men and ships in aid of the expedition. But in the catalogue of the army, where their names first occur, they are styled "good physicians;" and their skill in the cure of wounds is afterwards recorded in terms of high commendation. The profession of medicine became hereditary in the family of Æsculapius, and when divine honours were paid to him at Epidaurus, his temples were the depositaries of all the medical knowledge of the age, under the superintendence of his descendants, who were invested with the sacerdotal office. The veneration that was paid him in his native city continued to increase, and in the following century festivals and sacred games were instituted to his memory; at length temples were erected to him in various parts of Greece, and he took his rank among the established divinities of his country. After a lapse of many ages, in consequence of a fatal epidemic which raged at Rome, the Senate were commanded, by the Sybilline oracle, to transfer the worship of Æsculapius to their city. A solemn embassy was accordingly appointed for this purpose; when the god was said to have been stolen from his native place under the form of a serpent, and thus carried into Italy, where he was received with transport. The plague of course immediately ceased, his divine authority was recognized, and he continued ever after to hold a distinguished rank in the Roman mythology.

That Æsculapius was a real personage, who was deified after his death for his supposed services to mankind, is highly probable, although it may be extremely difficult to obtain any authentic information concerning him; but as his sons are enumerated by Homer among the Grecian chiefs, we may infer, that he himself held this rank. It is to be remarked, that there is no allusion in the Iliad to his divine nature, a fact which affords some proof of his actual existence, and likewise tends to substantiate the antiquity of the poem. The only circumstance that leads to the supposition of his being merely a fabulous character is, that there was more than one individual to whom the name has been applied; there were memorials of two in Greece, and there was a tradition of one still more ancient in Egypt. (Cicero, *Nat. Deor.* iii. 32.) We have no means of arriving at any certainty respecting their separate existence, or their rival claims. We may conjecture that different states of Greece might have taken advantage of vague reports, or doubtful legends, in order to obtain the honour of ranking so distinguished a personage among their fellow countrymen, or in consequence of the celebrity which the name had acquired, in the first instance, others might have assumed it, or have had it applied to them, from a similarity in their characters or pursuits. Upon the whole, we may conclude, that the father of Machaon and Podalirius, who was afterwards worshipped at Epidaurus, is the person to whom the name of Æsculapius most properly belongs, and to whom a considerable improvement in the science, or at least the art of medicine, is to be attributed.

Where there is so much uncertainty respecting the history of the individual, and where no written documents exist, it would be in vain to expect that we could obtain any accurate knowledge of the opinions or practice of Æsculapius. Much learned discussion has, indeed, taken place on this subject; but the only question which we shall notice at present is, whether he ever undertook the treatment of internal complaints, or whether he did not confine himself to what is more strictly denominated surgery? Some of the most learned of the ancients adopted this idea, (Celsus, *lib.* 1. *pref.*; Pliny, *lib.* 29. 1.) and there are many circumstances which lead us to conclude, that most of the diseases, which now fall under the care of the physician, were, in the earlier stages of society, conceived to be inflicted on men by the immediate agency of the deity, and to be either altogether irremediable, or to be averted solely by prayers and religious ceremonies. To the above question it is perhaps impossible to give more than a conjectural answer, but, upon the whole, it appears the most probable, that the principal part of the practice of those times was surgical, and yet that there were some cases in which the cure of internal diseases was attempted, and appropriate remedies applied for this purpose. Le Clerc, *Hist. Med.* 1, 1, 15.

After the death of the sons of Æsculapius, we have almost a total blank in the history of medicine, comprehending an interval of many centuries, in which there is no distinct record of any considerable improvement having been made, nor any individual so far distinguished above his contemporaries, as to require particular notice. The practice of medicine in Greece was confined, during this period, to the descendants of Æsculapius, who were, at the same time, the priests of his temples, and obtained the name of Asclepiades. The temples that were erected to him were numerous, but there were three that acquired a superior degree of celebrity; those of Cos, Cnidos, and Rhodes. From the imperfect account which we have of the practice of the Asclepiades, we may conceive that it consisted, in a great degree, of those circumstances which were calculated to operate upon the imagination of the patients. Various rites and ceremonies were imposed upon them, and after their minds were thus wrought up to a proper pitch of enthusiasm, they were taught to expect, that the method of cure would be revealed to them in dreams, that were inspired by the direct interference of the divinity. (Cabanis *on Medical Science*, c. i. § 1. p. 51.) It is unnecessary to remark, that a very lucrative trade was thus opened to the priests of Æsculapius, which we may readily suppose they did not fail to improve; and we may conceive, that by a dexterous management of the votaries, who crowded to the holy shrines for their assistance, they might obtain considerable credit for their medical skill. An important part of the ceremonial which was enjoined upon those who came to obtain advice was, repeated ablution, and immersion in the sacred springs that were attached to the temples. This practice, although employed solely as a religious rite, must have been, in many cases, immediately conducive to the removal of disease; and being combined with the pure air of those retreats, the beautiful scenery with which they were surrounded, and the freedom from cares and occupations, would operate very forcibly on the health of the patients; like the medicinal springs which are resorted to in modern times, and which are indebted for their celebrity to these adventitious circumstances, as well as to their medical properties. But although a large portion of the practice of the Asclepiades consisted of charms and mysteries, or of such remedies as were better adapted to act upon the mind than the body, yet it is probable that, from the ample means of experience which they enjoyed, they would acquire some valuable knowledge respecting the phenomena of disease and the operation of medicines. Their experience would be much assisted by the custom which the patients adopted, of leaving behind them a narrative, of the nature of their case, and the means of cure which had been employed, so that, to a certain extent, these temples became schools of medicine, and were the repositories of all the medical science which then existed. (Plinii *Nat. Hist.* 29; Cabanis, p. 55.) Some ancient inscriptions have been preserved by the learned and indefatigable Gruter, which are supposed to have been the memorials that were left by the patients who came to consult the priests of Æsculapius.* Pliny relates that Hippocrates transcribed many of these records; and it is the opinion of some critics that the precepts called *Coacæ prenotiones*, which are generally printed among his works, consisted of the maxims which he collected from the temple of Cos.

It has been already remarked, that after the death of Æsculapius, medicine remained, for a very long period, nearly stationary. During eight centuries the practice was almost exclusively confined to the Asclepiades; and notwithstanding the circumstance mentioned above, which would necessarily lead to the accumulation of knowledge, yet the real additions that were made appear to have been very inconsiderable. Indeed the records that we possess are so scanty, as to give us but little information respecting the progress that actually took place, so that we are only enabled to form any opinion concerning it from some incidental expressions of Hippocrates or his contemporaries. There is a tradition, that purgatives were first administered by Melampus, and that bleeding was first practised by Podalirius, or, according to some accounts, by Æsculapius; (vide Gronov. *ubi supra*,) but little reliance, however, can be placed upon these reports, and all that we know with certainty upon the subject is, that bleeding and purging are spoken of by Hippocrates as common practices in his time; and it may be inferred, had been so for a long period before he wrote. We are informed that the temples of Æsculapius, which arrived at the highest degree of celebrity, were those of Cnidos and Cos; and that they each of them acquired a reputation for a different species of excellence. The Asclepiades who were attached to the former were more strictly empirical, and confined themselves to the mere collection of facts, while those of Cos approached more to the dogmatic system, and attempted to blend reason with experience; but although there may have been some shade of distinction between them, there is every reason to believe that they were all grossly ignorant, and that their general character was very contemptible.

After medicine had remained so long in the hands of the priesthood, and had advanced so little under their influence, a ray of light burst upon it from a different quarter. About the end of the sixth century before the Christian æra, a spirit of philosophical research began to take possession of the human mind; and science, which had hitherto been pursued for the most selfish purposes, and had been mysteriously concealed from the vulgar, was now destined to fall into hands much better adapted for its cultivation and general diffusion. Some of the earlier Grecian philosophers appeared at this time, and embracing the whole range of nature in their inquiries, they paid considerable attention to the structure and properties of the human body. The first of these illustrious characters, of whom it is certainly known, that he applied himself to the study of anatomy or physiology, is Pythagoras. Although many transactions in the life of this celebrated man are involved in much obscurity, and bear a fabulous aspect, yet there is no doubt that he devoted his whole time to the pursuit of knowledge; that, for this purpose, he left his native country, and remained for many years in Egypt, where he placed himself under the direction of the priests, and was initiated into all their sacred mysteries, as well as into their scientific principles. It was currently reported by the ancients, that he afterwards spent some time among the Chaldean sages and the Persian Magi, but this part of his history seems to rest upon more doubtful authority. (Cicero, *de fin.* 5, 29. Valer. Maxim. 8. 7.) When he had thus acquired all the information which the state of the world then afforded, he fixed his residence at Crotona, in the south of Italy, and established a school of philosophy in that city, which became highly celebrated, maintained its reputatian for a considerable length of time, and produced a very important effect upon the general state of knowledge. There seems little reason to doubt that, among his other acquirements, Pythagoras attended to the state of the animal body,* and speculated upon its functions, but it appears no less certain, that he did not practise medicine as a profession, but that whatever progress he might make in this, or any of the collateral sciences, it was more with the general view of a philosophical inquirer into nature, than of a physician. The same thing appears to have been the case with some other celebrated men, who were either his immediate pupils, or followed him in the same pursuits, and adopted many of his leading doctrines. Among these we may rank Empedocles, Democritus, and Heraclitus, who may all be considered as Pythagoreans, although they had each of them their peculiar tenets, and in some respects deviated very widely from the philosophy of their master.

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* Gruteri corp. inscrip. p. 71. The following are taken from the ruins of the temple of Æsculapius, on an Island in the Tyber.

Hisce diebus, Cajo cuidam cæco, oraculum edidit. Veniret ad sacrum altare: et genua flecteret; à parte dextra veniret ad lævam, et poneret 5 digitos super altare; et elevaret manum, et poneret, super proprios oculos. Et recte vidit, populo præsente; et congratulante, quod grandia miracula fierent, sub imperatore nostro Antonio.

Lucio affecto lateris dolore, et desperato ab omnibus hominibus, oraculum reddidit deus. Veniret; et ex tribomo tolleret cinerem, et una cum vino commisceret, et poneret supra latus. Et convaluit; et publice gratias egit deo; et populus congratulatus est illi.

Sanguinem revomenti Juliano, desperato ab omnibus hominibus, ex oraculo respondit Deus. Veniret; et ex tribomo caperet nucleos pini, et comederet, una cum melle per tres dies. Et convaluit; et veniens publice gratias edit, præsente populo.

Valerio Apro milite, cæco, oraculum reddidit deus. Veniret; et acciperet sanguinem ex gallo albo, admiscens mel; et collyrium conficeret, et tribus diebus uteretur, supra oculos. Et vidit; et venit; et gratias egit publice, deo.

It is not easy to determine what actual additions were made to medicine by the Grecian philosophers, but it is probable that they were not very great. The state of science in Egypt, whence their knowledge was derived, we have already alluded to. The practice there was entirely empirical, and was, at the same time, combined with much superstition; physiology and pathology seem to have been totally unknown; and although it has been supposed that anatomy had made considerable advances in that country, in consequence of the opportunity which the inhabitants enjoyed of examining the dead subject, while they were preparing it for embalment; yet, when we reflect how this operation was performed, we cannot conceive that any great insight into the structure of the body could be derived from it. We may indeed suppose that the genius of Pythagoras had led him to make some valuable additions to the knowledge which he imported from Egypt; and we are expressly told that Democritus dissected the bodies of animals, for the purpose of discovering their organization. Yet the advantage which the science of medicine would derive from the labours of the philosophers of Greece was principally of an indirect nature. It was more by exciting a fondness for research, and by giving their contemporaries a taste for inquiry, than by the extent and accuracy of their observations, that they are entitled to our notice in tracing the history of medicine. They rescued it from the trammels of superstition and mystery, and what had before been regarded with awe and reverence, as a fit subject for those alone who were favoured with supernatural illumination, was now laid open for general investigation. The reasoning which they employed was, indeed, for the most part, incorrect, and was deduced, not from any examination of the laws of vitality, nor even from an accurate observation of facts, but from those speculative or metaphysical principles, which formed the foundation of their respective doctrines, on the nature of matter, and its supposed powers and agencies. Thus Pythagoras introduced his peculiar notions about numbers, and the influence of the heavenly bodies, Democritus applied his hypothesis of atoms and a vacuum, and Heraclitus his theory of ethers and elements, to explain the effects of disease. So seducing were these speculations, and such firm possession did they retain of the mind, that for many ages they formed the basis of the most esteemed medical theories, and even at this day their influence is not entirely annihilated. If we may credit the assertion of Pliny, (*Nat. Hist.* xxix. 1.) Acron is the first who is entitled to the merit of attempting the study of medicine upon correct principles, and of adopting what may be styled a system of rational empiricism; but we are too little acquainted with his history and character to form any certain conclusion upon the subject. We must not omit to notice Herodicus, who is said to have paid particular attention to the effect of the gymnastic exercises, which formed so important an object in the education of the Grecian youth, and to have employed them systematically, as a means of restoring or promoting the health of his patients. (Plato, *de Repub.*) On this account he is styled the inventor of the gymnastic medicine, a part of the science which was assiduously cultivated by the ancients, but we have no direct history either of his principles or his practice. The gymnasiarchs, or superintendents of the gymnastic schools that were established all over Greece, were obliged, from the nature of their office, to possess a certain degree of medical knowledge. The health of the young men was intrusted to their care; they took charge of any accident that occurred to their pupils, which required surgical assistance, and probably also of their internal diseases, while, at the same time, they laid down such regulations respecting exercise and diet, as were supposed the most conducive to the growth and vigour of the body. Some knowledge of the nature of the human frame, and of its diseases, must have been acquired from the ample experience of those who were connected with these institutions, and we may presume that Herodicus, who was himself a gymnasiarch, might in this way acquire some useful information.

With respect to the state of medicine at this period we may therefore conclude, that although it had now been cultivated in Greece 800 or 900 years, yet it had made but little progress. While it remained in the hands of the Asclepiades, it consisted almost entirely of a routine of the same empirical practice, combined with a large portion of superstition and mystery; and when it at length attracted the attention of the philosophers, and was made to assume more of the aspect of a science, it was placed upon a false foundation, and was rendered subservient to principles, most of which were in themselves fallacious, and were altogether inapplicable to the functions of the living body. Yet it must be confessed that the Pythagoreans conferred a real benefit upon medicine, by bringing it more into general notice; and if they did not themselves discover the direct path of investigation, they at least made it more easy to be detected by others.

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* Ælian, however, is of a different opinion, *Hist. Var.* 4. 17.

It was at this period, about the middle of the 5th century before Christ, that Hippocrates appeared, a man endowed with talents of a very superior order, peculiarly adapted to the cultivation of medical science. He introduced into it a new method of investigation, effected a total revolution in both opinions and practice, and maintained an unrivalled authority over the minds of his successors for many centuries, so that, by the unanimous consent of posterity, he has acquired the honourable appellation of the father of medicine. His prime merit, and that which may be considered as laying the foundation for all his celebrity, consists in his detaching the study of the human frame from the philosophical systems of his contemporaries, and in applying himself more to the accurate observation of phenomena, than to abstruse speculations concerning their causes. His medical hypotheses profess to be the simple deduction of facts, and his method of cure to be founded upon a rational empiricism, in which his reasoning is always built upon the basis of experience. He is said to have been the 18th in lineal descent from Æsculapius. It appears that he was brought up among the Asclepiades, who belonged to the temple of Cos, and that from his earliest youth, he had his attention directed to those pursuits, to which he devoted the remainder of his life. It is not very certain from what other source, except the traditionary records of the temple, he derived his information, but it is generally supposed that he studied philosophy under Heraclitus, and medicine under Herodicus. Considering the great celebrity which he has since acquired, it is a little remarkable that none of his contemporaries, or immediate successors, have given any accurate account of the events of his life; but there are sufficient documents to show, that he resided at different times in various places, and it is probable, that his celebrity caused him to receive invitations from the different parts of Greece, to attend upon individuals of distinguished rank, or to check the ravages of prevailing epidemics.*

The works that he left behind him are numerous, and many of them nearly in a perfect state; but it unfortunately happens, that his high reputation has been the cause of several treatises being attributed to him, which there is every reason to suppose are not genuine. Much learned criticism has been bestowed upon the volumes which are published under his name, and there are very few, even of the most admired classical writers, whose works have been more frequently edited, or been the subject of more learned commentaries.

No circumstance, indeed, more clearly proves the high estimation in which the writings of Hippocrates have been at all times held, than the number and talents of those who have been employed in explaining and elucidating them. Galen, who speaks of him with almost an extravagant degree of enthusiasm, perpetually refers to his works, and devoted a great portion of his writings to amplyfying the speculations and hypotheses of his predecessor. Plato, Celsus, Pliny, and Suidas, mention him with the greatest respect. Erotien published a glossary for the purpose of explaining the doubtful terms that occur in his writings, and at the revival of letters, Hollerius, Cornarius, Mercurialis, Heurnius, Duretus, Fœsius, and others, who were among the most learned men of the age, conceived that they could not render a more important service to the science of medicine, than by becoming the commentators of Hippocrates. The most complete production of this kind is the edition of Hippocrates by Fœsius, in which every circumstance connected with those celebrated treatises is collected with the most indefatigable industry. He gives a list of the criticisms and commentaries which had been written upon them, and it appears that at the time when he made the collection, no less than 137 different authors had published upon the subject of the aphorisms alone.

Besides the general interest which has been experienced, with respect to any circumstance connected with so celebrated a character, there are particular causes why his writings have been the subject of so much learned discussion. To one of these we have already referred, the number of works which have been falsely attributed to him; and another cause is the mutilated state in which some treatises have been preserved, which seem to possess the greatest claim to authenticity; and in the third place, we may mention, the abruptness and obscurity of his style. Without entering minutely into these points, we may observe, with respect to the first of them, that it has been the principal object with some of the commentators upon Hippocrates, from the time of Erotien to the present day, to discriminate between the genuine writings of the father of medicine, and those which have been improperly attributed to him. Lists have been made out by different writers, and they have employed much learning in defending their respective opinions; yet the result is, that every succeeding author has produced a catalogue different from his predecessor, and it appears that we are at this time in possession of little more certain knowledge upon the question, than when it first began to be discussed.

Erotien is supposed to have been the first who formed a classification of the works published under the name of Hippocrates. Galen, without laying down a regular canon, has stated his opinion respecting many of them in the course of his commentaries; soon after the revival of letters, a judicious arrangement was proposed by Mercurialis, more lately Haller has exercised his sagacity upon this point, and it has been still farther investigated by the learned Gruner. Mercurialis divides the whole into four classes. The first consists of those treatises which are the undisputed productions of Hippocrates; the second, of those which were drawn up by his sons or pupils, from materials left by him; the third, of those which were written by his relations or pupils, upon his principles, but with which he had no direct connexion; and the fourth, of those with which he had no connexion of any kind, and to which his name has been attached without any foundation. Gruner, after a very full discussion of the subject, reduced the genuine works of Hippocrates to ten, and Akermann has, more lately, still farther diminished their number to seven, a reduction which will appear very considerable, when we bear in mind, that the whole number usually printed in the best editions, as in that of Fœsius, amounts to more than 60.

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* The account of his having been at Athens during the plague is probably not true

The second circumstance which we mentioned, the mutilated state of the writings of Hippocrates, often renders it a very difficult task to ascertain his meaning on certain points, and has consequently given rise to much critical disquisition. The imperfections and interpolations that occur in the manuscripts of Hippocrates, are perhaps not more numerous than those in other ancient writings, but the nature of the subject greatly increases the difficulty of supplying the deficiencies or rectifying the errors. In works of science, and especially of a science which is necessarily obscure in many of its parts, the meaning and scope of the whole treatise may depend upon a single word, and that may possibly be a word not to be met with in any other contemporary author. Le Clerc furnishes a good illustration of the different interpolations that may be put upon a train of reasoning, by the alteration of a single letter, and other examples of the same kind might be quoted.

The peculiarity of Hippocrates' style, the third circumstance which we mentioned, as having given occasion to an unusual number of critical remarks, is admitted by all those who have paid the most attention to his writings, and whose learning enables them to be the best judges. (Conringii, *Introd.* c. 3. § 8.; Clerc, *Hist.* i. 3, 30. Aikin's *Gen. Biog.*) Its brevity and abruptness are referred to by Galen, and the very encomium which he passes upon it, is itself a proof of the point in question. Even some of the ancients to whom the Greek language was their native tongue, were not always able to comprehend his meaning, and if Erotien, who lived in the first century before Christ, thought it necessary to write a glossary to explain his obscure expressions, we may readily imagine how great must be the difficulty in the present day. Under these circumstances it becomes a subject of extreme uncertainty, to determine really what are the doctrines of Hippocrates, and on many points, it must be confessed, we can never expect to decide with perfect confidence. But among the different opinions that have prevailed, there are some treatises which all critics agree in considering as genuine, and with respect to some principles, both of theory and of practice, they are so frequently referred to, and so fully explained in different places, that even should there be any doubt concerning an individual passage, there are others sufficiently numerous to support its authority. Our limits will not permit us to enter farther into these discussions, but the great celebrity of the author, and the real value of his acknowledged productions, will render it proper for us to give a summary of his opinions, and to point out the extent of the improvement which he effected in medicine.

In estimating the merits of Hippocrates, we shall briefly consider, in succession, his general principles in philosophy, his physiology, his pathology, his anatomy, and lastly, his talents as a practitioner. It has been already stated that Hippocrates derived his philosophy from the school of Heraclitus, who, although essentially a Pythagorean, is generally regarded as the founder of a distinct sect, to which his name is attached. His leading doctrines were, that fire is the origin of all things; that it consists of minute particles, which are in perpetual motion; and that by the collision and combustion of these ethereal particles, and by the different degrees of density which the compounds acquire, the four elements are produced. (Enfield's *Hist. Phil.* b. ii. c. 14. p. 441.) Many traces of this doctrine may be found in the writings which are ascribed to Hippocrates; but it was remarked by Celsus, as reflecting the greatest credit upon his wisdom and sagacity, that he first separated medicine from philosophy. His principles were not assumed *à priori*, as was the case with his predecessors and contemporaries, but he professed to derive his knowledge from experience, and to examine how far external circumstances actually affected the constitution and functions of the body. Although his execution is not in every instance equal to his design, yet he proceeded upon a correct method of investigation; and there are few among his numerous successors, until the middle of the last century, who have kept hypothesis more in subjection to observation, or have permitted theory to interfere less with practice. In common with the followers of Pythagoras, he adopted some opinions, which we consider as totally unfounded, and others which we cannot but regard as absurd; but we have reason to believe, that he possessed an extensive acquaintance with many branches of science, and that he omitted no means of acquiring all the information which the age afforded.

In his physiology we observe many traces of the Pythagorean philosophy; but, along with these, a large proportion of what appears to be original, or, at least, what has not been traced to any other source. One of his leading tenets is, that a principle which he styles nature, (φυσις,) directs and superintends all our corporeal actions and movements. To this principle he attributes a kind of intelligence; and he conceives that one of its most important offices is, to attach to the body what is beneficial, and to reject from it what would prove injurious—a sentiment which, although expressed in different ways, and clothed in a more or less mysterious form, has continued to be a popular doctrine to the present day. Besides this nature, which is regarded as the prime agent, there are other subordinate principles or faculties, (δυναμεις) which are active in the production of the different functions. With respect to the body, he conceives it to be composed of three kinds of substances, solids, fluids, and spirits, which are themselves formed by different combinations of the four primary elements. The nature of the body is materially affected by the four elements which enter into its composition, as well as by the four qualities, of hot, cold, moist, and dry; which, by their respective combinations and proportions, produce the four temperaments: these are considered as original predispositions existing in the body, influencing both its mental and corporeal character, and laying a foundation for the diseases to which the individual is especially liable. In his account of the different functions of the body, although we observe many marks of sagacity and acuteness, yet he must, upon the whole, be considered as possessing no very accurate information. His acquaintance with the structure of the parts was very limited, but little was known about the nature of the external agents which influence the corporeal organs, while the use of the organs themselves was merely derived from conjecture, which was often vague, and resting upon false analogies. There is also a degree of inaccuracy in the use of his terms, which is both the effect and the cause of an imperfect state of the science. He employs the same word to signify an artery, a vein, and a nerve, (φλεψ,) and he confounds nerves with tendons. He speaks in an unintelligible manner of the spirits; by which he sometimes seems to mean what has in modern times been styled the nervous fluid, and has been conceived to be the immediate source of sensation, while at other times he applies the same term to what can bear no relation to this agent. In some places the veins are spoken of as the organs by which these spirits are conveyed to the different parts of the body, while the common centre of sensation is supposed to reside in the left ventricle of the heart.

The pathology of Hippocrates, as might be expected, is equally incorrect with his physiology, and indeed it abounds even more in speculations and hypotheses, which we now regard as completely without foundation. He supposes that the stars have an influence over the body; a doctrine which was probably, in the first instance, derived from the Chaldeans; and he adopted the mysterious opinions of Pythagoras, respecting the occult power of particular numbers. He attributed many diseases to air, which enters the stomach along with the food and drink, and is afterwards carried both into the solids and fluids, and dispersed all over the body. This air serves the purpose of cooling the blood; but if it exist in too large a proportion, it repels the vital fluid from the extremities and surface to the internal parts, where it produces obstruction, sometimes terminating in fever, and at other times in inflammation. But the most important of the doctrines of Hippocrates on this subject was, that the fluids are generally the seat of disease; a doctrine which laid the foundation for the humoral pathology, and formed the basis of all our medical hypotheses, until the commencement of the 18th century. Besides the four elements and the four qualities which enter into the constitution, and influence the physical properties of all material substances, the body was supposed to consist principally of four fluids or humours, blood, bile, phlegm, and black bile. According to the predominancy of one or other of these fluids in the body, it acquired its peculiar temperament, and they also are conceived to be the immediate cause of disease, by their respective excess or deficiency. Hence one of the most important points to be attended to in practice, is the due regulation of these humours, and this is to be attained principally by the evacuation of such of them as exist in too great quantity. The doctrine of crises and critical days forms an important part of the pathology of Hippocrates. By the crisis of a disease he appears to have understood, any sudden change in its symptoms, accompanied by a spontaneous evacuation; and many of his observations on this subject are still considered as correct. He farther conceived that there was a tendency in certain diseases to produce this crisis on particular days, an opinion which he advanced as the result of observation, and which is still supposed, by some writers, to be not entirely without foundation; yet there is reason to suspect that it originated from a false theory, and that, at all events, it was pushed to an unwarrantable extent. Among his general doctrines of disease, he laid much stress upon the operation of external agents, and particularly upon temperature, moisture, and the peculiar condition of the atmosphere, the effects of which were obvious, although the cause was often obscure. In all these points it is admitted that he made many correct observations, and that he displayed a degree of sagacity which has seldom been surpassed.

There has been much controversy respecting the anatomical knowledge of Hippocrates; some of his commentators have not hesitated to ascribe to him an acquaintance with the structure of the body, approaching to the accuracy of modern times; and it has even been asserted that he understood the circulation of the blood, as it was afterwards described by Harvey. But this is without foundation. Indeed there is every reason to believe, that his knowledge of anatomy was very limited, and that it was chiefly derived from the external appearance of the body, or from an occasional inspection of the internal parts of brutes. Indeed, it is not certain that, in this department, Hippocrates materially surpassed his contemporaries; a circumstance which is to be attributed to the difficulty of obtaining anatomical knowledge at the period when he lived, and which reflects no discredit either upon his understanding or his industry. Le Clerc enters into a long discussion on this subject; and after examining each part of it in detail, with his usual learning and candour, he concludes, that the knowledge which Hippocrates possessed of anatomy was both very imperfect and very incorrect. *Hist. de Med.* 1. 3. 3. See also Lauth, *Hist. d'Anat.* and Goulin, *Art. Medicine*, *Encyc. Meth.*

But it is on his correct description of diseases, his sagacity in forming prognoses, and his skill in laying down the diagnostic symptoms, that the high reputation of Hippocrates was originally acquired, and upon which it ultimately depends. He is said to have been the inventor of clinical medicine; and he probably has as just a claim to the invention as can be given to any one, with respect to a science which depends more upon a gradual accumulation of knowledge, than the discovery of any insulated fact or particular principle. He is certainly the first writer of whom we have any correct information, who accurately stated the phenomena of disease, and generalized the symptoms of particular cases, so that we are able to recognize them from his description, although made so long ago, and under such different circumstances. His commentators have very minutely examined the nature of the morbid affections which are mentioned by Hippocrates; and it has been said, that there are no less than 300 which he has distinctly detailed, and to which he has assigned specific names. In this brief sketch we shall only be able to point out a few of the leading principles which guided his practice, and the indications of cure to which he particularly directed his attention.

The great principle which influenced the practice of Hippocratas, is the existence and action of what he calls *nature*, and its superintending power over all the functions and movements of the body. He supposed, that whenever the system was deranged by any disturbing cause, the efforts of nature were always directed to repair the injury; and that the only object of the physician was to watch over these efforts, and to repress or excite them according to circumstances. This opinion generally led him to adopt, what we should now call inert practice, as he seldom made any great effort to counteract the morbid symptoms, or even to curtail the duration of a disease. The second principle was, that every disease, or at least that every disease which is sufficiently acute or definite to enable us to mark its whole progress, must terminate by a critical evacuation; and that as diseases originate from the prevalence of some morbid humour existing in the body, so the cure must necessarily be effected by the discharge of this humour. The humours, as has been already observed, were reduced to four primary ones, and it was supposed that there were means by which each of these humours might be specially acted upon, so as to promote its discharge. A third principle, which we often meet with in the writings of Hippocrates, and which, in some measure, appears contrary to his leading doctrine of the all-sufficient energy of nature, is, that a disease is to be cured by inducing a contrary or opposite state; if it depend upon repletion, we are to use evacuation; if upon evacuation, we are to employ repletion; if any of the four qualities are in excess, as for example, moisture or dryness, we must endeavour to induce the contrary qualities. Such a mode of reasoning is, no doubt, in its principle correct; but it will be found, that in the execution of his plan, he often attempted impossible indications, and not unfrequently employed means little adequate to insure the desired effect.

With respect to the remedies that were used by Hippocrates, it will appear, from the tendency of his pathological doctrines, that they consisted principally of evacuants. Among the evacuants, those upon which he most depended were purgatives, and of these he was in the habit of prescribing a great variety, differing much in their degree of activity, and in their supposed power of operating upon different parts of the system; he also employed diuretics and sodorifics; drew blood both by the lancet and by scarification, employed the cupping glasses, inserted issues, and used injections. He was fond of external applications, and had great faith in the efficacy of ointments, liniments, and cataplasms. His materia medica, as we learn from his commentators, was tolerably ample, although many of those substances, which we now regard as the most powerful remedies, were unknown to him. The active metallic preparations were not introduced into medicine until long after his time, the spiritous and ethereal compounds were likewise unknown, while anodynes and narcotics were seldom had recourse to. Upon the whole, we regard Hippocrates as one of those geniuses who are destined to appear in the infancy of science, and raise it at once to a state of comparative perfection. Like Homer and Shakspeare in epic and dramatic poetry, and like Michael Angelo and Raphael in the art of design, Hippocrates not only created medicine, but brought it to a state of advancement which it did not surpass for many centuries.

CHAP. II.

The second Period of the History of Medicine, from the Death of Hippocrates to that of Galen.

The powerful influence which the talents of Hippocrates had on the science of medicine, and the revolution which he effected by his writings, brought it into a state, in which it remained for a considerable length of time without much alteration. According to the custom of the age, he transmitted his art, embellished with all the improvements which he introduced into it, to his sons Thessalus and Draco, and to his son-in-law Polybus. They appear to have supported the credit of the family, and the latter especially is considered as having written some of the treatises, which are always printed along with the works of his father-in-law. We do not learn, however, that they made any important improvements; nor, among the number of those who devoted themselves at this period to the study of medicine, do we meet with any of distinguished celebrity, until Diocles of Carystus. He is characterized by Le Clerc as the first physician who had acquired any celebrity since the time of Hippocrates. Except some fragments, and those of doubtful authority, none of his works have come down to our times; and we know little of his particular opinions, or of the individual improvements which he introduced into medicine: but we are informed, that in his philosophy he adopted the tenets of Pythagoras; and we learn from Galen, that in his fundamental principles of practice, he did not materially differ from Hippocrates.

The next physician, whose reputation was so considerable as to entitle him to be mentioned in this brief sketch, is Praxagoras of Cos, who was of the family of the Asclepiades, and the last of this race that arrived at any distinguished eminence. Except the mere fact of his general celebrity, we have few traces left, either of his personal or literary history. He is said to have paid much attention to anatomy, to have made observations on the pulse, and to have been distinguished, as well by his extensive knowledge, as by the great use which he made of reasoning in support of his doctrines; but, from the specimens of his opinions which are transmitted to us, it does not appear that his physiology and pathology were more correct than those of his predecessors. Another physician of ancient Greece, that requires to be noticed, is Chrysippus, who became famous, rather from the innovations which he made, and from his decisive condemnation of former opinions and practices, than from any real improvements which he effected in the science. He is said by Pliny "to have overthrown, by an extraordinary talent for argumentation, the maxims of the physicians who had preceded him," a remark which is confirmed by the account of Galen. Among the new principles which he adopted, we are informed that he never admitted the employment of bleeding, and that he disliked all active purgatives; from which brief account we may venture to conclude, that he deprived himself of some of the most powerful instruments of his art, and that his practice, if not positively injurious, must have been feeble and inefficient.

Besides those who employed their whole time in the study of medicine, or who pursued it as their sole profession, we must not omit to mention two characters, of the highest reputation for their general science, Plato and Aristotle, both of whom devoted a portion of their researches to the investigation of those branches of natural knowledge that are nearly connected with medicine. They are too well known to render it necessary for us to give any account of their history or pursuits. In the extent of their information, both with respect to physical and moral science, they occupied the first rank among their contemporaries, and for many centuries they enjoyed an almost unrivalled share of celebrity. Plato has left no work which can be considered as professedly treating upon any department of medicine; but in his dialogue, entitled *Timæus*, he has entered into many physiological speculations, and stated his opinions respecting the nature of many of the powers and functions of the body. But it does not appear that the science has benefited by his labours: he seems not to have applied himself, in any degree, to the acquisition of actual knowledge, but to have been merely engaged in forming hypotheses, and those often founded upon the most vague and fanciful analogies, and strongly tinctured with the mystical spirit which pervaded all his writings. Stanley's *Hist. of Phil.* c. 17. p. 23.

The genius of Aristotle, and the course in which it was directed, were, in many respects, better adapted for the improvement of medical knowledge than that of Plato. He devoted a considerable portion of his time and attention to the prosecution of physical science, and he left some treatises expressly on the subject of physiology. He was the first among the ancients who advanced comparative anatomy and natural history to any considerable degree of perfection; and he both enjoyed great advantages for obtaining information on these topics, and cultivated these advantages with much assiduity. The influence which Aristotle possessed over the minds of posterity was considerably greater than that of Plato, or any other individual; so that, for nearly 2000 years, he must be considered as having reigned absolutely over the opinions of mankind, in all branches of philosophy. It is admitted that he had an extensive acquaintance with natural objects, and was a diligent observer of physical phenomena; but notwithstanding this quality, and the actual advances which he made in science, it may be doubted whether the ultimate effect which he produced was not unfavourable. After the revival of letters, he obtained so complete an ascendancy over the minds of all learned men, and was regarded with such a degree of superstitious veneration, that, for a long period, no one dared to dispute his authority, or even to extend their inquiries beyond the limits which he had prescribed to them.

For nearly a century after the death of Hippocrates, Greece continued to be the exclusive seat of medical knowledge, when, in consequence of the establishment of the library and museum at Alexandria by the Ptolemies, it was transplanted into Egypt. From this time Alexandria was the great school of medicine that was resorted to by all countries; a pre-eminence which it retained for many ages. Among the founders of the Alexandrian school, or at least among the earliest and most celebrated of its professors, were Erasistratus and Herophilus. There is some uncertainty respecting both the exact period and the place of their nativity, as well as about the subsequent events of their lives, nor have any of their works been transmitted to us; but, from the accounts of Galen, Cœlius Aurelianus, and others, we have much interesting information about their opinions, and the improvements which they introduced into medicine. Their names are recorded in conjunction with each other, as being the first who dissected the human subject, the bodies of criminals having been granted them by the king for this purpose; and there was a current report among the ancients, that they were permitted to open the bodies while they were still alive. But this was probably an exaggerated statement, depending upon the superstitious horror that has prevailed, in all ages, against the examination of the human body, even after death. They are, however, universally allowed to have been the first who obtained any correct notions of anatomy, and who possessed the opportunity of pointing out the difference between the structure of the human body and that of brutes. They ascertained many new and important facts respecting the brain and the nerves, and are stated to have discovered the valves of the heart; and there is some reason to suppose that they had an imperfect knowledge even of the lacteals. It does not, however, appear that their physiology and pathology were much improved by their anatomical discoveries. Erasistratus supposed that the blood was naturally all lodged in the veins, while the office of the arteries was to contain merely air, and that the cause of inflammation, and many other diseases, depended upon the blood getting from the veins into the arteries. (Pliny; Galen, *De Diff. Puls.* lib. ii. cap. 3.) He was the pupil of Chrysippus, and adopted all his prejudices against bleeding and purging, which were strengthened by his own hypothesis respecting the offices of the different parts of the sanguiferous system. It seems that he made use of very few powerful remedies of any description, and that he in general trusted the cure of diseases more to the regulation of the diet than to medicine. The anatomical fame of Herophilus, although commonly blended with that of Erasistratus, has gained a still higher degree of estimation; and, from the concurring testimony of the ancients, we cannot hesitate to admit that he made many improvements in the science, of the first importance. From the same authority we learn, that he paid particular attention to the pulse, (Galen, *De Venæ Sect.*) which, before his time, had not been much noticed; but he seems to have attempted to introduce into practice a number of minute distinctions concerning it, which were derived more from hypothesis than from actual observation.

About the period when the school of Alexandria first rose into estimation, a remarkable schism took place in medicine, which was the subject of long and warm controversy among the ancients, and subsists, in a certain degree, even to the present day. This was occasioned by the rise of the two rival sects, the dogmatists and the empirics. The great point of dispute between the two parties that engaged in this controversy was, how far we are to introduce theory into medicine, or in what degree it is to influence our practice. According to the dogmatists, or, as they are sometimes called, the rationalists, before we attempt to cure diseases, we are to make ourselves acquainted with the structure and functions of the body, with the changes which are produced in it by various morbid causes, and with the action of remedies in removing or counteracting them. The empirics, on the contrary, maintain, that the knowledge which the dogmatists suppose to be necessary is not to be attained; that, by our utmost efforts and most elaborate researches, we can never acquire that insight into the operations of the animal body which will serve to direct our practice; and, consequently, that our sole guide must be experience, either derived from personal observation, or the testimony of others. It is not easy to determine with certainty to whom these sects owe their origin. The dogmatists have been anxious to claim Hippocrates as their founder; but, although he often employed theoretical reasoning to illustrate or explain his practice, and not unfrequently appears to have adopted a certain plan of treatment, in consequence of some hypothetical opinions, yet his leading principle was always to prefer observation to hypothesis, and to make experience his guide, whenever it could be obtained. We are informed, however, that his sons or descendants were less cautious in this respect than their ancestor; and it seems to have been the general opinion among the ancients, that to them the origin of the dogmatists is to be attributed. We may presume that the errors and inconsistencies that would necessarily arise, from proceeding upon the very imperfect knowledge of the human body which they possessed, would tend to produce the opposite extreme; that an unwarrantable and excessive disrelish for all theoretical reasoning would be induced, and that a foundation would thus be laid for that state of opinion which gave rise to the doctrine of the empirics. To whom the regular establishment of the sect is due, or by whom the tenets were first maintained in a systematic form, is a point that was controverted even among the ancients; so that there is little probability of our being able to arrive at any certainty on the subject, in the present day. Pliny has ascribed the origin of this sect to Acron of Agrigentum, who was contemporary with, or even prior to Hippocrates, and others have attributed it to Philinus of Cos, who was a pupil of Herophilus; but Celsus positively mentions Serapion of Alexandria as the first who decisively supported the doctrine, that theoretical reasoning is of no avail in medicine, and that our sole dependence is to be placed upon practical experience. The opinion of Celsus is the one which was generally adopted by the ancients, and seems to stand upon the best foundation: it is, however, not precisely determined at what period Serapion lived, nor is there much known respecting his history. He is said to have been the pupil of Herophilus; and, from some quotations that have been preserved from his writings, and the specimens that are handed down of his tenets, it seems that he retained much of the practice of Hippocrates, although he rejected his hypotheses.

Most of the ancient physicians seem to have attached themselves to one or other of these sects, and their writings abound with the statements which were employed on either side of the question. Although there were men of perhaps equally great abilities in both parties, yet it happens that the works of all the professed empirics have perished; so that the reasoning which they contained is only known through the statement of their adversaries. A general view of the controversy has been drawn up by Celsus, in so candid and perspicuous a manner, that we cannot present our readers with any thing more satisfactory than an abstract of his account of it. The dogmatists laid it down, as the leading principle on which they proceeded, that the practice of medicine requires a knowledge both of the concealed or essential cause of diseases, and of the obvious cause; also of the natural actions of the body, and of its internal structure. By the concealed causes, they mean those actions not cognizable by the senses, which relate to the elements or principles of which the body is composed, and which actually constitute the deviation from health; and they argue, that no one is competent to cure disease until he is acquainted with the natural condition of these actions. Now, these have been accounted for upon a great variety of principles. By some they have been ascribed to an undue proportion of the four elements; by others, to a depravation of the humours. Some have maintained that the seat of disease is in the spirits; Erasistratus contended, that it is produced by the blood passing from the veins into the arteries; and Asclepiades, by the corpuscles obstructing the small pores. But it is evident, they say, that as we adopt one or other of these causes of disease, we must proceed upon a different principle in effecting its removal. It is admitted that experiments are necassary; but these cannot be entered upon with any prospect of advantage, unless we are directed in them by principles of reasoning. Cases frequently occur which are new to us, and where no previous experience can direct our conduct; so that nothing can enable us to determine beforehand, why any plan of treatment should be more useful than another, except by investigating their causes, and reasoning concerning them.

With respect to the natural actions of the body, such as the functions of respiration and digestion, the motion of the heart, and other corporeal operations, how is it possible that we can counteract the diseases which depend upon their derangement, without being acquainted with their nature and their healthy condition. Nothing is more important to the well-being of the system than the proper action of the digestive organs; but, on this point, the utmost diversity of opinions has existed. Some ascribe digestion to the attrition of the food in the stomach, others to its putrefaction, and others to its concoction by heat; but before we can apply our remedies, it is necessary for us to know upon which of these causes the action of the stomach depends. And, with respect to pains or diseases of the internal parts of the body, no one could know in what way he is to apply remedies for these pains and diseases, unless he was acquainted with the nature and situation of these parts, and with their condition in the state of health. On this account, it is absolutely necessary to examine the dead subject, to know the position of the different viscera, their relation to each other, and their natural actions, without which all our attempts to relieve their diseases must be directed at random, and will probably be without effect.

To this reasoning of the dogmatists, which, it must be allowed, is plausible, and is, in some respects, just, the empirics were not wanting in what they conceived to be a satisfactory answer. If the obvious causes of disease, which are immediately cognizable by the senses, and require no abstruse train of reasoning for their detection, be removed, they conceive it quite unnecessary to attempt the investigation of the concealed causes, which, after all, are beyond our power to discover. The diversity of opinion, which is admitted by the dogmatists to exist, is a sufficient proof of this position, for all their reasoning has produced no approach to an agreement of sentiment on any one point; and, with respect to practice, it appears that, whatever be their speculative opinions, their success in curing diseases is nearly equal. Even where the causes are the most obvious, as in the cases of external injuries, it does not follow that the remedies must be so likewise; for reasoning would be of no avail, were we not informed by experience what was the best method of treating such cases. But if this be true in these instances, where the causes are manifest, how much more will it be so with respect to such as are confessedly obscure, and concerning which we see, as a matter of fact, that the utmost diversity of opinion has always prevailed. With respect to the reasoning which is employed in medicine, it is asked, Does it teach the same thing with experience, or does it lead to a contrary conclusion? If it only teaches us what we might learn from experience, it is superfluous; but if it lead to the contrary conclusion, it must be absolutely injurious. With respect to the occurrence of any new form of disease, no real light would be thrown upon it by having recourse to any obscure cause or abstruse speculation: we must rather endeavour to discover to what well known affection this new case bears the nearest resemblance, and make a trial of those remedies which, from this kind of analogy, seem the most adapted to it. The empirics do not pretend to dispense with the use of reason, but they contend it is a misapplication of it to spend it upon the investigation of these obscure causes, because the immediate object of the physician is not to ascertain what produces the disease, but to know what will remove it. We should adopt the same method of proceeding in medicine as in all the other arts of life. Neither a labourer nor a philosopher would become skilled in their respective departments by disputation, but by practice and experience; and, in proportion to the subtilty and intricacy in the point of dispute, so much the more necessary is it to have recourse to these certain guides.

It has been thought that Celsus, in his view of the two theories, has given rather too favourable an account of the doctrines of the empirics; but his general conclusion is candid and judicious, and is nearly the same which we should adopt in the present day; that each of them, in the extreme, is objectionable, and that the true plan of proceeding consists in maintaining a medium between the two. And, indeed, this was, in a great measure, the case, even with those individuals belonging to the two sects, who have most pertinaciously supported their respective tenets; for the dogmatists perpetually appeal to experience, and the empirics, although they restrain the use of reasoning, do not altogether prohibit its employment. The chief difference between them is not so much in the admission or rejection of experience and of reasoning, as in this circumstance, that the dogmatists entered more deeply into speculations respecting the nature of the animal body, and the principles by which its operations are directed, while the empirics paid but little attention to these topics, and always, in the first instance, professed to be guided by experience. We are perhaps not in possession of sufficient facts to qualify us to judge of the two parties, either with respect to their merits as practitioners, or the effect which they produced upon the general state of medical science. The dogmatists would be more disposed, from the system which they adopted, to commit their opinions to writing, and introduce into their works learned discussions, and scientific researches, which would cause them to be perused with more interest, and render their authors more celebrated. But it appears that the temporary or local fame of many of the empirics was at least as great as that of any of the dogmatists; and, in one department, their labours were peculiarly valuable—that of the materia medica. As their principles prevented them from indulging themselves in forming speculations, or wasting their energies in abstruse hypotheses, their attention was more directed to observing the operation of pharmaceutical substances on the body; and, accordingly, it appears that they had the merit of introducing into practice many of the most valuable medicines.*

In tracing the history of medicine, we must advert to a circumstance, which is said by Celsus to have occurred about this period, perhaps more really important than the controversy between the dogmatists and the empirics, although at the time it excited less attention —the division of the art of medicine into different parts. Hitherto the whole had been exercised by one person alone; but it was now formed into three distinct branches, which were regarded as affording separate occupations for different persons: they were styled dietetics, pharmacy, and surgery. These terms had not, however, precisely the same signification which they possess in modern times: the first did not refer to diet alone, but to every circumstance which is concerned in the general management of the patient; and the second implied, not the compounding of drugs merely, but the manual application of all the means of removing disease, being nearly synonymous with the practice of our surgeon-apothecaries. The third was appropriated to the practice in what we now call surgical diseases, except that the actual operations were generally conceived to belong to the second branch of the art. It was to the first of these divisions that the title of medicine was restricted, and its professors were, after this time, exclusively called physicians.

As has been observed above, the school of Alexandria supported its credit for many centuries, and produced a succession of learned men, who each contributed his share to the perfection of the art. But our attention must now be directed to the progress of medicine in Rome. For a long time after the foundation of the city, and even after she had extended her conquests beyond the boundaries of Italy, Rome is said by Pliny to have been without physicians, by which we are not to conclude that no attempts were made to cure diseases, but that there were no men of science engaged in the practice of medicine, and that it consisted principally in superstitious ceremonies, abundant examples of which we meet with in the Roman historians, or the application of traditionary remedies, which were employed by persons who did not make medicine a distinct profession. Pliny informs us that the introduction of medicine into Rome was posterior to that of the arts and sciences in general, and that it had been, as it were, banished by the unanimous consent of the citizens, in consequence of their disgust for it. So singular a fact may be thought to require a more direct evidence than the concise narrative of Pliny; but the account which he gives is, that the first individual who professed to practice at Rome was Archagathus, a native of Peloponnesus, who came into Italy about 200 years before Christ. His practice seems to have been entirely surgical, and was principally confined to the cure of wounds. He was at first received by the Romans with great respect, and had even a residence assigned him at the public expense; but his frequent use of the knife and caustics rendered him unpopular, and this unpopularity extended itself to the profession at large. About a century elapsed, during which we have no account of any physician of eminence, when Asclepiades made his appearance, a man of singular character and talents, and who had the address to raise himself to a high degree of celebrity. He was a native of Bithynia, and originally settled in Rome as a teacher of rhetoric; but not meeting with success in this line, he turned his attention to physic. With this kind of training, and without a regular medical education, it is not surprising that he should begin by decrying the principles and practice of all his predecessors, and endeavour to persuade those about him that he had discovered a new and more compendious road to medical knowledge. Of anatomy he was ignorant, and therefore pretended to despise it; and he is said to have particularly directed his attack against the patient researches of Hippocrates into the symptoms and phenomena of disease. He formed a new theory of pathology, which was derived from the corpuscularean philosophy of Epicurus, the fundamental doctrine of which was, that the body consists of a system of atoms and pores, and that disease is produced by the obstruction of the pores, or the irregular distribution of the atoms. He had the discretion to refrain from the use of active remedies; and he seems, for the most part, to have depended principally upon diet, exercise, baths, and frictions. He is said to have been the first who prescribed wine to his patients, and, in general, to have indulged them in all their inclinations; from which circumstance, and probably also from the credit which mankind are disposed to give to those who have sufficient assurance to set a high value upon their own abilities, he acquired an unprecedented degree of reputation, and left behind him a sect which long maintained its popularity. But although we must conclude that the knowledge of Asclepiades was scanty, and that his pretensions were many of them arrogant and unfounded, he appears to have been a man of acuteness, and to have introduced some important improvements into medicine, among which we may mention the division of diseases into the two great classes of acute and chronic, a division which has certainly a foundation in nature, and which he probably was led to by actual observation, but which he accommodated to his theory, by supposing that the first class depended upon a constriction of the pores, or an obstruction of them by too large a proportion of the atoms, and the other upon a relaxed state of the pores, or a deficiency of atoms.

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* On the controversy between the Dogmatists and the Empirics, see Galen, *de ESubfig. mpire;* Celsus *in Praef;* Barchusen, *Dissert.* 10, 11; Le Clerc, *Hist. Med.* part 2. liv. 2.

The place which Asclepiades had occupied in public estimation was, after his death, filled by his pupil Themison, a native of Laodicea, who had the honour of becoming the founder of a new sect, which, for a considerable time, divided the empire of opinion with the dogmatists and empirics. It was styled the Methodic Sect. In the establishment of this system Themison appears to have been influenced by the tenets which he had imbibed from his master; and, like him, he endeavoured to simplify the theory and practice of medicine, and reduce it to a few common principles, which might be easily acquired, and always kept in view. In some respects he must be considered as holding a middle course between the dogmatists and the empirics. He rejected the concealed causes and abstruse physiological speculations of the former, but he did not, like the latter, think that we are entirely to discard all consideration respecting the state of the system. On the contrary, he made this the basis, both of his hypothesis and practice; for he laid it down as a fundamental position, that there are two morbid conditions of the body, which are contrary to each other—a state of constriction, and a state of relaxation. To these he added a third state, compounded of the two former—the mixed state; and to the three he referred all diseases, and likewise the operation of all remedies, which he conceived acted either as astringents or relaxants, and prescribed them accordingly. As we have observed above, we may trace the origin of Themison's pathology to the obstruction and relaxation of Asclepiades, although more cautiously expressed, and cleared of the incumbrance of the pores and atoms. It is obvious that this theory of the methodics is fundamentally opposite to the humoral pathology of Hippocrates, which was afterwards embraced and amplified by Galen, and prevailed universally until the last century, when the origin of disease was again referred to the solids; and a system was broached, not very dissimilar to that of Themison's, which still retains possession of our popular forms of speech. It has been very justly objected to his arrangement of diseases, that, even admitting the correctness of his principles, with respect to the existence of the states of constriction and relaxation, yet we are unable to form any conception how the two could exist at the same time; for it does not appear that, by his mixed diseases, he meant to designate those where there was an irregularity in the different parts of the body, or in different organs, but that he considered this mixed state as pervading the whole system.

We are enabled to form a tolerably correct idea of the practical tendency of the doctrines of the methodics from Cœlius Aurelianus, who was a strenuous supporter of this sect, and whose writings have come down to our times in a sufficiently entire state. Judging from this source, and also from the observations of Galen and others, who have either referred to or controverted their tenets, we may conclude that the disciples of Themison were diligent in the observation and collection of facts; that they watched attentively the phenomena of disease; and that, in laying down their indications of cure, they frequently displayed considerable acuteness. They were less learned than the dogmatists, but perhaps not less successful practitioners; and they seem to have held a kind of middle course, both in the formation of hypotheses, and the application of remedies; for while their practice was less decisive than that of the supporters of the dogmatic sect, it was more efficacious than that of Asclepiades and the contemporary empirics. In reducing all diseases and all remedies to the two principles of constriction and relaxation, they would no doubt find insurmountable difficulties; not knowing in which department to place them, they would often be obliged to have recourse to their mixed or neutral state, which was little better than an asylum for their ignorance.

While the simplicity of the methodic system must be considered as a powerful recommendation of it, by removing a large mass of idle speculation and useless discussion, and thus permitting the mind to be directed to objects much more worthy of attention, the same circumstance was productive of occasional disadvantage, by the facility which it afforded to bold and daring innovators to carry this simplicity to an unwarrantable length, and thus to persuade those who were incapable of forming a correct judgment, that they were producing a more effectual reform in medical science. This was attempted by Thessalus, who lived about fifty years after Themison, and who, although of low birth and very defective education, contrived, by his artifices, to acquire considerable wealth and reputation. Like all those who endeavour to supply, by arrogance, what they want in knowledge, he began by railing at the system of his predecessors, and by boasting that he had discovered the true theory of medicine; that no one before him had done any thing that was valuable on the subject; and he concluded by conferring upon himself the title of the Conqueror of Physicians. It will not be necessary to enter very minutely into the opinions of one, who must be mentioned only to be condemned; but, as a matter of historical fact, it appears that he adopted the speculations of Asclepiades, respecting atoms and pores, and those of Themison, concerning constriction and relaxation; but he disregarded all the minute observations of the latter; and, while he professed to carry the methodic system to a state of perfection, he, in fact, stripped it of a great part of what constituted its real value. The only part of Thessalus's practice which we shall notice, is what he called *metasyncrisis*, which consisted in producing an entire change in the state of the body; a change which he pretended to be able to effect, by a plan which he substituted for that of the empirics, who professed to correct the morbid states of the system, or of the Hippocrateans, who proposed to watch and superintend the operations of nature. The term *metasyncrisis* was afterwards currently employed in medicine, and was adopted by many writers, who entirely rejected both the speculations and the practice of Thessalus.

The methodic sect, under its different modifications, became the prevailing system at Rome, and may rank among its supporters many men of great eminence in their profession. Among these, the first in point of time, and perhaps also of abilities, was Soranus. Little is known respecting either his private or his literary history; and it seems probable that there are at least three physicians of that name who lived nearly about the same time, and upon whose respective claims it is not very easy to decide. The most celebrated of them is said to have been a native of Ephesus, to have resided some time at Alexandria, where he probably acquired his medical knowledge, and finally to have settled in Rome. All his writings are supposed to have perished; for it seems that the anatomical treatise which is extant, on the uterus, is rather to be referred to the second Soranus. But the loss of these works is the less to be regretted, as the most valuable information which they contained has been transmitted to us by Cœlius Aurelianus.

Cœlius Aurelianus was a strict adherent of the methodic sect; and from his work, which has come down to us, we may form a sufficiently clear conception of their principles and practice. It is quite uncertain where he lived, and what was his native place; but the best informed critics suppose him to have been a native of Africa, and to have flourished in the first century after Christ. From some expressions which he employs, it has been generally supposed that his book is merely a translation of Soranus; but this does not appear to be exactly the case. It seems that he generally adopted his opinions, and was, for the most part, his devoted follower; but it is evident, that, in all cases, he could not be the translator of Soranus, in the literal sense of the word; because he occasionally mentions his name, for the purpose of showing where he dissents from him. But whatever may be our determination on this point, it is universally agreed, that the work which we possess of Cœlius Aurelianus is a very valuable relic of antiquity, not only as affording a complete view of the opinions and practice of one of the most distinguished sects, but as containing much useful and curious information respecting the phenomena of disease, of which he describes a greater variety than any other ancient author. He is particularly ample on all practical points, and his writings possess an incidental value, from the frequent reference which he makes to his contemporaries and predecessors, of whom we have sometimes no knowledge, except from his remarks. He divides diseases into acute and chronic, a division which nearly corresponds with that of diseases of constriction and relaxation; and he refers the operation of remedies to their power in counteracting these two morbid states. A common principle in the practice of Cœlius Aurelianus is, to attach importance only to such indications of cure as are evident, and to refrain from entering into any subtile discussions concerning the concealed properties or essences of things. He was anxious to avoid definitions of disease, and in their place he substituted descriptions; and so careful was he not to implicate himself in theoretical controversies, that he generally declines inquiring into the part which is the seat of disease, thinking it sufficient to ascertain the correct train of symptoms to which a certain name should be attached, and what remedies were the best adapted for the disease thus identified. The means which he adopted were simple, and he always preferred the employment of diet, exercise, &c. to any more active treatment. He condemned, for the most part, what are called specifics, conceiving their effects to be very dubious, and often founded upon prejudice or misapprehension—an opinion which is perhaps not far from the truth; but he fell into the egregious error of banishing purgatives from his list of remedies, because he could not reconcile their operation to his theory of constriction and relaxation. He seldom, if ever, drew blood by the lancet; but he admitted the use of leeches and cupping-glasses, because it was conceived that these were relaxing, and therefore proper to counteract the constriction which exists in inflammatory diseases.

The doctrine of Themison, as we remarked above, soon became very popular at Rome; and a great number of the most distinguished physicians ranked themselves under its banners. But it met with some opposers, who still adhered to the dogmatists and empirics; and, after some time, the methodics themselves introduced innovations into the system of their master, and were divided into two or more separate sects. Of these, the most noted were the Episynthetic, the Eclectic, and the Pneumatic. It seems, however, not to be certainly ascertained, whether the two former of these are entitled to the appellation of distinct sects, or whether both these denominations do not refer to the same system; and, even if we admit them to be distinct, we must consider them as nearly allied to each other. From what we know of their tenets, we learn that they did not profess to have discovered any new principles, or to have projected any improvement in theory, but to have founded their doctrines upon the judicious selection which they made from the opinions and practices of others. They seem, indeed, to have approached to the physicians of our own times: they had no prevailing hypothesis, or at least none upon which they laid much stress; but they rather employed themselves in collecting facts and observations from all quarters, and arranged them according to their practical application. The pneumatics, although generally classed as a sect emanating from the methodic system, seem scarcely to have any claim to be considered in this light; for, from the scanty materials which are left of them, they do not seem to have insisted upon the leading point of constriction and relaxation, nor, in general, to have embraced those opinions which characterized the acknowledged disciples of Themison. They derived their name from the introduction of what they call spirit into their pathology, which they regarded as the fifth element, in addition to the four recognized by the old Greek philosophers. What idea was attached to the term *spirit*, or how it differed from the air of the original elements, is not easy to decide; and we shall probably be induced to conclude, that there is no one distinct idea which can apply to all the passages where the word is used. Little, however, is known, either of the sect in general, or of the opinions of its adherents: and it seems never to have risen to any considerable degree of reputation.

Among the eclectics we must place two methodical writers of considerable eminence, who flourished about the period at which we are now arrived—Celsus and Aretæus. Although their works are some of the most valuable that have come down to us, yet very little is known of their personal history; and even the exact time when they lived is a question that is still undecided by the most learned critics. Celsus, however, would appear to have been the older of the two; and, from some incidental expressions which he employs, as well as from the manner in which he is spoken of by others, the most probable conjecture is, that he published in the reign of Tiberius. He is the first native of Rome whose writings, on any medical topic, have been preserved; and his style possesses so much of the purity of the Augustan age, that it has served as a model of latinity to all modern physicians. It has been doubted whether Celsus was an actual practitioner, or whether he only studied medicine as a branch of natural philosophy. The way in which he is spoken of by Pliny would incline us to adopt this latter opinion; and we learn from Quintilian and Columella, (Quintilianus. *Inst.* lib. iii. c. 2.; Columella *de Re Rustica*, lib. i. c. 1.) that he wrote on many other subjects besides medicine. We have perhaps no means of deciding the point at issue; but, however it be determined, there seems every reason to conclude that he was well versed in the state of medical science, and acquainted with the phenomena of disease.

The work of Celsus "on Medicine," is divided into eight books, the first four of which treat principally of internal diseases, while the remainder are more particularly appropriated to the description of external diseases, of surgical operations, and of pharmacy. He commences by an elegant sketch of the history of medicine, containing a judicious comparison of the two great sects, the Dogmatists and the Empirics, of which we have given an abstract above. Then he enters into the consideration of diet and therapeutics, and lays down many positions respecting pathology, which form the subject of the second book, while the third and fourth books are devoted to the description of particular diseases, with the mode of treatment. He has borrowed largely from Hippocrates, and has shown that he was fully sensible of his merits, as an accurate observer of morbid symptoms; but the author to whom he most frequently refers, and whom he appears, upon the whole, to have regarded as the highest authority, is Asclepiades. He however states the opinions and practice of different writers with so much candour, and is guided so much more by a judicious examination of the respective merits of each of them, than by a zealous devotion to any one hypothesis, that to none of the ancients is the title of eclectic more justly applicable. His practice in many cases approaches to that of Hipprocrates, in its simplicity, or even in its inertness, and consists more in regulating the efforts of nature, as they have been termed, and in promoting the natural crises, by the proper management of diet, exercise, air, and other circumstances, than by the administration of powerful remedies. On some occasions, however, he ventured upon a bolder plan of treatment; in particular, he was liberal in the use of blood-letting, and judged that many of the restrictions which were imposed by Hippocrates are unnecessary, or even injurious. His employment of the lancet was indeed more frequent than that of any of his predecessors; while, at the same time, he laid down strict rules for its use, and appears to have adhered to them without much deviation. These rules were in general judicious, and not very different from what might be adopted by the most enlightened practitioners of the present day: but it must be acknowledged, that, in one respect, he was unfortunately led astray by a false theory, and was consequently induced to discard the remedy, under the very circumstances in which it is often the most efficacious. In consequence of some notions respecting the crudity or want of concoction of the fluids, in the commencement of febrile diseases, he never admitted blood-letting, until this supposed process of concoction was completed; and he therefore, in many instances, must have permitted the period to pass by, when the loss of blood would have been most beneficial. With respect to purgatives, he was rather limited in their administration, and seems to have been too much afraid of their debilitating effects; when he did employ them, he generally preferred the milder ones.

In his management of fever he proceeded very much upon the plan of watching the operations of nature: for he conceives that the disease has a direct tendency to cure itself, without the intervention of art, except so far as to obviate any irregularity, or to prevent any extraneous circumstances from interfering with the natural process. After the manner of Asclepiades, in the commencement of fever, he carried the system of abstinence to a degree of extreme severity; and he even very much restricted his patients in the use of liquids of all descriptions. The Hippocratean doctrine of critical days he entirely disregarded, an opinion which he rests upon the authority of Asclepiades, and still farther confirms by his own observations. He arranges the different species of fever, according to their symptoms and progress, with considerable acuteness; and his descriptions of them accord, for the most part, with what we observe in our own times. Perhaps, however, the most interesting part of the work of Celsus is the two last books, which are on surgery, but these it does not fall under our province to examine. We shall only remark concerning them, that they are very valuable, both from the real information which they contain, as well as from their being the only correct and detailed account which we possess, of the state of this branch of the profession at the time he wrote. They exhibit demonstrable proof that surgery had made great advances; and we find that many of the capital operations, as they are termed, were understood, and generally practised by his contemporaries.

The history of Aretæus is still more involved in obscurity than that of Celsus; and the period when he flourished is at least equally uncertain. He has, however, currently obtained the name of the Cappadocian, from the supposed place of his nativity, although he is said to have practised at Rome; and the most probable conjecture seems to be, that he lived about the time of Vespasian. He wrote a general treatise on diseases; and he is inferior to none of the writers of antiquity in his description of symptoms, and particularly in the accuracy of his diagnostics. His practice, in its general features, resembles that of Hippocrates, being distinguished for its simplicity, and not much encumbered with refined speculation; but he paid much less attention to the natural actions of the system, and, on many occasions, did not scruple to interfere with or entirely to counteract them. He has generally been regarded as an Eclectic, and we conceive that he has a just claim to this denomination; but Le Clerc, from observing in his writings many traces of the doctrines of the Pneumatics, considers him as belonging to this sect, in which opinion he is followed by Cabanis. But the passages upon which this judgment is founded, in our estimation, only prove that he borrowed from this, as well as every other medical theory, and it does not appear that he has shown such a decided or exclusive attachment to this particular hypothesis, as to lead us to rank him among its adherents.

Aretæus divided all diseases into acute and chronic, like the Methodics; and there are many parts, both of his pathology and his practice, which strongly resemble their tenets, as laid down in the writings of Cœlius Aurelianus. He differs, however, from them in some fundamental particulars; contrary to their rules, he frequently prescribes purgatives, and those of the most active kind, such as elaterium and hellebore: he was not sparing in the use of the lancet; and, in some diseases, he even recommended that blood should be drawn in such quantities as to produce fainting. In his choice of emetics, as well as of purgatives, he often prefers those that are the most powerful in their operation; and is particularly attached to what he called the white hellebore; not so much from the copious evacuation which it produces, as from the kind of general shock which it effects in every part of the system. Upon the whole, we may regard Aretæus as a bold, but at the same time, as a sagacious practitioner; if he employs very active remedies, he uses them with the confidence of one who was familar with their action; and although, on many occasions, we may feel dissatisfied with his reasoning, yet, in all cases, we must admire the accuracy of his descriptions, and give him the highest credit for his correct observation of the phenomena of disease.

During the period of our history at which we are now arrived, when Rome, under the empire of the Cæsars had advanced to a state of the highest splendour and magnificence, medicine, as well as all the other arts, which are usually attendant upon a highly civilized condition of society, was cultivated there with much assiduity, and the names of many individuals have been transmitted to us, some of whom require to be briefly noticed. Except Celsus, all the physicians, who had hitherto distinguished themselves at Rome, were foreigners, principally from the different parts of Greece and Asia Minor. This circumstance is particularly noticed by Pliny, and may be attributed partly to the little progress which natural philosophy, and all the collateral branches of knowledge, had made among the Romans, and partly to the peculiar constitution of their society, by which it was considered as degrading for a free-born citizen to exercise any art for the purpose of pecuniary gain. On this account, as the necessity for medical assistance increased, and it became difficult to procure a sufficient supply from abroad, we find that slaves, or at least those who had formerly been in the servile condition, embraced the profession of medicine, and many of them rose to considerable eminence. One of the first of these, in point of celebrity, was Antonius Musa, who had the honour of being the physician of Augustus, and who was regarded as standing at the head of his profession. A part of his reputation he owed to the fortunate circumstance of his having cured the Emperor of a dangerous fever, after his life had been despaired of; and so great was the popularity which he acquired on this occasion, that wealth and dignities were heaped upon him without measure, and his statue was erected by the side of that of Æsculapius. His success appears to have been not entirely unmerited: for we learn, that his plan of treatment in this case consisted principally in substituting the external application of cold, and a cooling diet, for the warm bath, and the heating medicines, which had been before employed. We are informed that Musa was the pupil of Themison, and it is probable that he remained attached to the methodic sect; he appears to have been a man of general information, and respectable talents; and we may conclude, that he was not indebted merely to accident for the high rank which he acquired.

The next physician whom we shall notice, is Scribonius Largus, probably, like Musa, of servile condition, and who lived under the reign of Claudius. He is only deserving of our attention as the author of a work, which has come down to us, entitled "On the Composition of Medicine," consisting of a collection of prescriptions and nostrums of all kinds, placed together without arrangement or discrimination, and more valuable, as showing what the state of medical opinion was in his age, than from its intrinsic merit. Little is known of his personal history; but he appears to have been a man of deficient education, and inferior talents. His work is written in Latin, but in so harsh and impure a style, that critics have supposed it to have been originally composed in Greek, and translated into its present form at a later period. Of this, however, there is no direct evidence; and it is, upon the whole, more probable that the errors of the language and composition are to be ascribed to the author himself.

In the reign of Nero, lived Andromachus, said to have been a native of Crete, who, like Scribonius Largus, owes his reputation principally to the prescriptions and formulæ which he composed or collected; to one of which, the theriaca, a remarkable degree of celebrity has been attached. It was proposed by its inventor as a general antidote for all poisons, as well as a preventive or specific for all diseases; and so great was the confidence reposed in its power, that the Emperors had it prepared in the palace for their own special use, and spared no pains or expense in procuring the drugs which entered into its composition. Nor was its reputation confined to the age of its discovery; amidst all the revolutions of theory and practice, it still maintained its ground in the public estimation, so that even half a century ago, the theriac of Andromachus was admitted into our modern pharmacopœias, very nearly in the same form in which it had been composed 17 centuries before. About 60 different articles entered into this famous recipe, many of which were entirely inert; among the more active of the ingredients were a number of aromatics; but the one on which its chief virtue depended was opium. The substance, however, to which its beneficial effect as an antidote was ascribed, was the flesh of vipers, prepared in a peculiar manner, and with many precautions that were religiously adhered to. With respect to the real value of this compound, it is not necessary for us to make many observations; in spite of the concurring testimony of so many ages, we cannot hesitate to discredit all the specific powers that have been ascribed to it; and there is no practitioner of the present day, who would not prefer a simple opiate, or at least the combination of opium with some one aromatic, to the multifarious mass of Andromachus. Little is known respecting the hypothetical principles, or the practice of this physician; and, indeed, if he had himself the same confidence in his theriac which he wished to impress upon others, the knowledge of medicine would have been reduced into very narrow limits; for this single preparation was held out as a universal panacea for all diseases. He arrived, however, at great honours in his profession; and the title which he enjoyed, of Achiater, has given rise to much critical controversy. There is no doubt that this distinction was only conferred upon physicians of the first eminence; but various opinions have been maintained respecting the exact meaning of the term. Perhaps it is not possible to decide with certainty, what idea was originally attached to it; but the conjecture which we conceive to be the most probable, both from the etymology of the word and other circumstances connected with it, is, that it signified the principal physican attached to the establishment of the Emperor.

It seems that about this period, from causes which perhaps we are not altogether competent to assign, the study of pharmacy and the materia medica was particularly attended to. Several of the forms of medicaments, which are still in common use, were then either invented or perfected, while many new articles were introduced into practice, and much information was acquired concerning their natural history and their physical properties. For a large portion of this kind of knowledge we are indebted to Pliny, who may be regarded as the most profound naturalist of antiquity, and who, although not exclusively attached to the study of medicine, possessed a very extensive acquaintance with the various departments of the science. Another writer, whose name stands very high as a contributor to our knowledge of the materia medica, is Dioscorides. He is said to have been a native of Asia Minor, and to have pursued medicine as a regular profession; but, like many others in the same department, who lived about this period, scarcely any thing is known of his personal history. He wrote a treatise on the materia medica, which obtained a high degree of reputation at the time when it was published, and maintained its credit through many centuries, until the greater correctness of modern science has rendered it more an object of curiosity than of real value. He describes all the vegetables which were then used in medicine, amounting to some hundreds, and gives an acconnt of their supposed virtues; but his descriptions are frequently so brief and inaccurate, that we are unable to determine to what they refer, while his detail of the properties of the substances is chiefly empirical, and little directed either by rational principles of science, or by the correct deductions of experience. The high authority which was, for so long a time, attached to the work of Dioscorides, combined with the intricacy necessarily belonging to the subject, tended to make it a most copious theme for learned criticism; and the controversies and discussions to which it has given rise are almost infinite, and many of them yet undecided. With all his defects, however, we must not deny to Dioscorides the merit of patient research and great assiduity in the acquisition of knowledge; and we must attribute many of his errors more to the state of natural science when he lived, than to any want either of talent or of industry.

The only other physician of this period, of sufficient celebrity to deserve being noticed in this brief sketch, is Rufus, usually called the Ephesian. He is said to have published on various subjects; but the only authentic works of his which have been transmitted to us, are a small treatise on anatomy, one on the diseases of the urinary organs, and a fragment of one on purgative medicines. Of these, the anatomical treatise is the most valued; it is entitled, *The Greek names of the different parts of the body*, and consists of short descriptions, correctly written, and conveying an interesting view of the state of the science at this period. It is worthy of our observation, that the author, when pointing out the most eligible method of studying anatomy, recommends his pupils to select those animals which are the most similar to man in their form, as the best expedient for acquiring a competent knowledge of the human subject. He adds, that formerly the human body itself was employed in anatomical demonstrations, from which it seems a very obvious conclusion, that such demonstrations were not practised at the time when he wrote.

We have now brought down our history to nearly the 2d century of the Christian era, when a character arose, more celebrated than any which had hitherto appeared, not excepting Hippocrates himself,—Galen of Pergamus. We are informed that Galen possessed many advantages of birth and education; his father, who was a man of a respectable rank in life, spared no pains in the cultivation of the mind of his son, and in bestowing upon him every accomplishment that the age afforded. He studied philosophy in the schools of the Stoics, the Academics, the Peripatetics, and the Epicureans; and we are told, that while he found something to his taste in each of the three first, he totally rejected all the principles and reasonings of the last. He entered upon the study of medicine at seventeen, was placed under the tuition of different masters, and travelled into various countries for the purpose of professional improvement; but it is probable that he derived his knowledge principally from Alexandria, which still maintained its reputation. After passing a few years in his native city, he went to Rome; but, as it appears, not meeting there with that encouragement which he thought due to his talents, he returned to Pergamus. The pressing solicitations, however, of the Emperors Aurelius and Verus, who were now sensible of his distinguished merit, once more brought him back to the metropolis, and it is probable that this became his residence during the remainder of his life.

Galen was a man of extraordinary powers of mind, and of very considerable acquirements. He wrote much upon all topics connected with his profession, delivered his opinions with great confidence, and treated his antagonists and rivals, who were both numerous and respectable, with little ceremony, and even with arrogance. He indeed seems to have been fully aware of his own superiority; and it was a leading sentiment of his mind, on all occasions, that his opinions were certainly right, and those of his opponents certainly wrong. This principle, which is undoubtedly very remote from the spirit of true philosophy, would not have been tolerated in one of moderate abilities or of insufficient learning; but in Galen, it actually produced upon others the same impression which he experienced with respect to himself, for he was regarded as a kind of oracle in medicine; and he obtained, for many centuries, an ascendency over philosophical opinions which was only equalled by that of Aristotle. On this account, notwithstanding all his learning and his attainments, and the unwearied diligence which he bestowed upon the improvement of his profession, as well as of every collateral branch of the science, it may be questioned, whether the result of his labours was not ultimately prejudicial to the progress of science. For 1300 years after his death, no one dared to oppose his authority, either in point of fact or hypothesis; and it was even considered a kind of heresy to pass over the limits of investigation which he had assigned to medicine, or to suppose that he had left any thing to be discovered by his successors. Nor did this state of mind last through the dark ages alone; for a long time after the revival of letters, when certain individuals had ventured to call his authority in question, the great bulk of the learned still adhered to him, and it required some ages of controversy to reduce his reputation to its just standard. It would be a laborious, and not a very interesting task, to criticise singly all the voluminous writings of Galen, amounting to nearly 200 distinct treatises; it will be sufficient for our purpose to offer some observations upon his general principles, and upon the actual information which he possessed on the different topics more or less immediately connected with medicine.

Galen was a decided dogmatist; he professed to receive nothing upon the mere faith of reputed experience, but to give a reason for all that he believed, and to reduce all his knowledge within the limits of his theory. He was a warm admirer of Hippocrates; he speaks of him in terms almost of veneration; and would lead us to conceive, that he agrees with him in all his fundamental tenets, and that he aims at little more than to elucidate and amplify his principles. But although he sets out from the same point, he quickly deviates into a more intricate path, and soon becomes so involved in abstruse and complicated hypothesis, that we are no longer able to trace the simplicity of the original in the refined speculations of his commentator. The physiology of Galen is the department from which a large portion of his celebrity is derived; and when we compare his book "on the use of parts," with any analogous work published before this time, we cannot but be struck with the superiority of his information, and the ingenuity with which he applies it to the explanation of the animal economy. In his knowledge of minute anatomy, he probably far surpassed his contemporaries; and he made a greater number of real additions to our acquaintance with the structure of the body, than any other individual among the ancients. Yet, on both these subjects, he is not without considerable deficiencies and inaccuracies; his physiology is frequently built upon fallacious principles, and, even supposing them to be correct, is too often marked rather by a kind of whimsical ingenuity, than by that cautious discretion which is so necessary in the discussion of any intricate point of philosophical investigation. His diligence as an anatomist is highly commendable, and worthy of our warm admiration; but the encomiastic flattery of his followers, by the excess to which they have carried their devotion, has proved derogatory to his reputation. From many circumstances connected with the history of the age, as well as from his own candid confession, we may conclude that Galen rarely, if ever, dissected the human subject, but that he examined the bodies of apes and other animals, the most nearly resembling it; and from these, by making what he conceived the proper allowances, he draws up his descriptions. But his zealous disciples would not admit of what they thought an imperfection in the works of their master; and to such an extent did they carry this principle, that it was even considered as more probable that the human body should have undergone a permanent change in its anatomical structure, than that Galen could have committed an error.

In his pathology, he sets out with the four elements, and the four qualities of Hippocrates; and, like him, conceives that an alteration in the state of the fluids is the origin of all diseases; but he introduces so many minute distinctions, and combines these changes in such a variety of ways, that he gives an entirely new aspect to this part of the science, and has been generally regarded as the inventor of the celebrated theory of the humoralists, which was almost exclusively adopted in the principal schools of medicine for fifteen centuries. His practice was entirely accommodated to his theory; the indications of cure were founded upon the supposed powers of different remedies to correct the morbid states of the fluids; and medicines were regarded as either hot or cold, moist or dry, according as these qualities coincided with his hypothesis, or seemed to be supported by observation. Unfortunately, however, observation was much less employed than theory; and the medical writings of Galen consist more of subtile and refined reasoning, than of the investigation of causes, or the generalization of facts. Upon the whole, we consider Galen as one of the most illustrious ornaments of science; and there are few individuals, in any age, or of any profession, whose fame has been more extensive, or will be more durable; yet it must be admitted, on the other hand, that he affords a remarkable example of the employment of an incorrect method of philosophising, and exhibits a proof of the more powerful attachment of the human mind to abstruse hypothesis, than to the simple exposition of facts.

CHAP. III.

The Third Period of the History of Medicine, from the time of Galen, through the dark ages, to the revival of letters.

The superior talents of Galen, and the unrivalled reputation which he obtained, tended to repress all farther efforts for the improvement of medical science; and his immediate successors, regarding him as beyond the reach of competition, were satisfied with implicitly adopting his opinions, without attempting to inquire into their correctness, or to extend their application. The spirit of the times but too powerfully coincided with this feeling. The Roman empire began to exhibit unequivocal marks of decline: in every department of literature there was a deficiency of genius; and the utmost efforts of those who now held the first rank, could only produce an imperfect imitation of the great standards of excellence which adorned the Augustan age. Rome, in its most splendid period, was never remarkable for the cultivation of science; and, as we have already observed, very few of the physicians, who acquired any degree of celebrity, were born in Italy, or employed the Latin tongue.

Alexandria still continued to be the great seat of medical learning; and the few individuals who arrived at any eminence in medicine, for some centuries after the death of Galen, were natives either of Greece or Asia Minor, and wrote in the Greek language.

The first of these whom we shall notice, is Sextus Empiricus, who was probably a contemporary of Galen's, and who, although a physician by profession, is more known to posterity in his literary character. Those of his works which are extant, consist of treatises against the principles of the dogmatists, and display considerable talents, together with a complete acquaintance with all the ancient systems of philosophy. The denomination of Empiricus was probably given to him in consequence of the tenets which he adopted; but he may be regarded as the last scientific defender of that sect: for, after this period, the authority of Galen conspired with the character of the age, to turn the current of fashion in favour of abstruse speculations, and all the subtleties of scholastic learning. Oribasius, who was a native of Pergamus, flourished about the end of the fourth century. He wrote, as it is said, about 70 different treatises, several of which are preserved; they profess to be little more than compilations from former writers, especially from Galen, of whom he speaks in terms of unbounded admiration. There is little that can be considered as of intrinsic value in any part of his multifarious volumes; but there is one circumstance which gives a degree of incidental value to them, that, in his numerous quotations and abstracts, he has preserved a number of passages, of which the originals are lost, some of considerable interest, from the information which they contain; while, in other instances, the only remains which we have of some of the ancient authors, are the fragments that we meet with in these compilations.

Aetius lived more than a century after Oribasius. Like him, he was a voluminous compiler from Galen and other authors; to whom, however, he does not always sufficiently acknowledge his obligations. His works embrace almost all the topics connected with medicine; but the only part that possesses any claim to originality is the account of surgery, in which some operations are described that we do not meet with either in Celsus or in Galen. In his mention of the articles of the materia medica, he gives us likewise some curious details of the state of this department of the science, and particularly respecting the pharmacy of the Egyptians; but his materials are collected with so little discrimination, and contain so many marks of credulity and superstition, as strongly to indicate the defective judgment of the writer, as well as the declining knowledge of the age. In proof of this allegation, it is only necessary to remark, that Aetius describes and recommends various magical incantations among his remedies; a species of practice that had been discarded for many centuries, and which could not have been revived, except at a period when the human mind was verging to a state of barbarism.

Alexander, named from the place of his birth, Trallianus, lived about the middle of the sixth century; and, although principally a compiler, is, however, more original than either of the two last writers. He seems to have been a man of learning and of judgment, and to have borne a high rank in his profession. His practice exhibits marks of the simplicity of the Hippocratean school; and if, in his theories, he generally follows the footsteps of Galen, on some occasions he has the boldness to differ from him. In his description of the symptoms of disease, he not unfrequently writes with precision, and with an air of originality; his treatment is often judicious, and many of his prescriptions are ingenious; yet it must be admitted, that his works contain a considerable mixture of absurdity, and that, like Aetius, he places confidence in the operation of charms and amulets. In his arrangement of diseases, he begins with those of the head, and proceeds, through the different parts of the body, down to the feet; an arrangement which we might be more disposed to condemn as unscientific and inconvenient, had it not been adopted by some of the most learned among the moderns.

Nearly contemporary with Alexander is Paulus of Ægina; like him, principally a compiler, yet not without some originality both with respect to facts and opinions. He is said to have employed great diligence in the acquisition of the knowledge of his profession; and, for this purpose, to have travelled into different countries, and obtained all the information which the age afforded. His account of diseases is commended for its clearness and brevity, and he is celebrated as being the first who has given a correct and scientific view of midwifery, and who is certainly known to have practised this art. He excels in the description of surgical operations. He mentions some which are not to be met with in any preceding author; and for a long time his writings on this subject were made the basis of our most approved systems. Paulus was particularly esteemed by the Arabians; and it appears, that they frequently obtained their knowledge of the ancients more through the medium of his works, than from the perusal of the originals.

With Alexander and Paulus terminated the ancient Greek medicine; for, after this period, neither Greece nor Asia Minor produced a single medical writer of any degree of eminence. Compilations from the works of Galen were occasionally published; but even these rarely appeared, and are deficient in every quality which can give them a claim to our attention. If we except from this censure the name of Actuarius, who lived about the eleventh century, it is rather from the circumstance of his works containing the first hint of the application of chemistry to medicine, than from their intrinsic merit. It is not easy to ascertain when the first operation was practised to which we may correctly apply the term chemical. Something of the kind may be met with in the pharmaceutical writings that were published about the commencement of the Christian era; but they are mentioned in an incidental manner, and can scarcely be considered as even approaching to the formation of a new branch of science.

It is generally admitted, that the invention of chemistry, that department of natural philosophy which now forms so distinguished an object of research, is due to the Arabs. From what source this people derived their first intimation of this science, whether from the Egyptians, from the Greeks, or from the Indians, is still a subject of controversy; nor are we able to ascertain what were the circumstances which immediately induced them to direct their attention to it. But it was undoubtedly in Arabia that chemistry was first regularly prosecuted, and the first books that we possess, professedly on this subject, issued from that country. It is not, however, our business to enquire minutely into the origin of chemistry, but a very interesting question occurs, and one intimately connected with our subject, respecting the period when chemistry was first applied to medicine.

This question is, however, involved in a part of the subject to which we must now turn our attention—the progress which was made in medicine itself by the Arabians. After the followers of Mahomet had carried their arms through a large part of the civilized world, and had spread devastation in all quarters, an interval of repose ensued, and their rulers seemed disposed to employ the arts of peace in the embellishment of that power which had been acquired by the most destructive arts of warfare. Learning and science were assiduously cultivated; the works of the Greek philosophers were perused with avidity, and they acquired as great a degree of authority over the minds of the Arabians, as they had formerly obtained in Greece and Italy. Medicine especially became a prime object of their attention, and at a time when the Europeans were involved in ignorance, or remained in a state of profound inaction, the Saracens were busily employed in transcribing and commenting upon Galen, and, what is still more important, in making many considerable additions to medical science. Their patronage of the arts was not confined to their native country, but was extended along with their conquests, and Spain, which was for some time under their power, became a distinguished seat of Arabian literature. The first of the Saracenic physicians of whom we have any distinct account, and whose genuine writings have been transmitted to us, is Serapion, who lived about the end of the 8th century. Among his works, which we now possess, is a general abstract of the practice of medicine, principally compiled from the ancients, but also containing some original observations, and likewise a treatise on the materia medica, in which we have a copious account of the simple substances, and the pharmaceutical preparations, which were then in common use.

About a century after Serapion, flourished the celebrated Rhazes, a man of superior talents, and of extensive learning and accomplishments. He was a native of Persia, but he studied at Bagdat, and practised in that city, where he arrived at the highest honours of his profession. His writings are very numerous, and display an intimate acquaintance with the works of his predecessors, as well as a familiarity with the phenomena of disease. Many of them retained a high degree of reputation in the medical schools of Europe after the revival of letters, and they are still referred to us as giving an account of some diseases, which either originated about the time of Rhazes, or had not been before distinctly noticed. Among these, the most remarkable is the history which he gives of the small-pox, which was first accurately described by this author; while, at the same time, he gives a curious and interesting account of the practice that was adopted by the Arabians, together with their hypothetical notions respecting its nature and origin. The treatment consists principally in evacuations, and the other parts of the antiphlogistic plan, and is not very remote from that of the most judicious physicians of the present day, after all the revolutions of theory and practice that have taken place during ten centuries. He wrote a set of aphorisms, deduced from his own practice, which are valuable records both of facts and opinions; and besides these, he published several large works, which consist principally of compilations from Galen, and the other Greek physicians. These are, however, for the most part, ill digested, and collected without much discrimination. Upon the whole, we must rank Rhazes among the improvers of medicine, although, at the same time, we may admit, that the amonnt of his actual improvements is scarcely adequate to the diligence with which he cultivated his profession, or to the extent of his acquirements.

Among the more distinguished of the Arabian physicians, Mesue is always included; much uncertainty, however, attaches to his history and character, in consequence, as it appears, of there having been two individuals of this name, and probably of the same family, who, although they lived at the distance of two centuries from each other, seem to have been confounded together. The one who has the greatest claim to our notice, is said to have flourished in the tenth century; to have professed the Christian religion, although a native of Bagdat; and to have practised at Cairo. There is some doubt of the genuineness of the writings usually ascribed to him, but those which pass under his name are on pharmacy and the materia medica, and are now merely objects of curiosity, as exhibiting a picture of the opinions of the age in which he lived.

A little later than this period, at the end of the 10th, and the commencement of the 11th century, lived Avicenna, a philosopher and physician, who attained a degree of celebrity, which for a long time almost rivalled that of Hippocrates and Galen. At an early age he exhibited marks of genius, and every means were employed for its cultivation. He was placed under the care of the first masters, and acquired all the learning and accomplishments which then formed a part of the education of youth. Together with a ready apprehension, an ardent thirst for information, and unwearied industry, he possessed an enthusiastic state of mind, almost amounting to fanaticism, and it is said, that when he met with any difficulty in his studies, he endeavoured to obtain by prayer that supernatural illumination, which was to supply the deficiencies of his mental powers. His abilities soon attracted the attention of the court, where he remained for some time, highly honoured and respected; but he unfortunately became involved in political intrigues, in consequence of which he was kept for many years in confinement, and by which his life seems to have been prematurely terminated. Avicenna published a large collection of works, on a variety of topics, both metaphysical, philosophical, and medical. He was a devoted admirer of Aristotle and Galen, and it seems to have been the prime and ultimate object of his researches to make himself acquainted with their tenets; and that he supposed little remained to be done but to apply them to the explanation of every phenomenon, and to obviate the apparent objections to their application. His chief professional work is called the canon of medicine, and consists of a laborious, but ill digested and servile compilation of all that had been written by the Greek physicians, on every branch of medical science. Yet notwithstanding these defects, partly from the magnitude of the performance, and the learning of the author, and partly, perhaps, from some incidental circumstances, which contributed to raise its reputation, the canon of Avicenna obtained the highest celebrity, not only among his own countrymen, but with the Europeans, so that it was the principal text-book adopted in the different schools, until after the revival of letters. It has gone through numerous editions, and has been abstracted, abridged, and epitomized, under a variety of forms, and even so late as the middle of the 17th century, it was translated into Latin, with abundance of notes and commentaries.

In the 12th century lived Albucasis, who acquired almost as high a character for his skill in surgery, as Avicenna had obtained for his knowledge of medicine. His writings show him to have been a man of extensive information, and he introduced many improvements into his art, which before that time had been much neglected. He appears to have been a bold and daring operator, and he employed, what we should now consider a severe kind of practice, making frequent use of the knife and the cautery, and subjecting his patients to much more suffering than would be thought necessary in modern times. He also published an abstract of medical practice, which displays considerable experience, and shows that his knowledge was not confined to a single department of the profession. His surgical works have been frequently edited; they were for a long time employed as a text-book, and regarded as the standard of practice.

To complete this sketch of the Arabian school of medicine, we must notice two eminent men, of Saracenic descent and education, both natives of Spain, Avenzoar and Averroes. The first of these lived in the 11th and 12th centuries, was a native of Seville, and had both a father and a son in the same profession with himself, to which circumstance may probably be attributed the unusual period of 135 years, which has been assigned to his life. He seems to have been a man of talents and information, and a diligent inquirer into the phenomena of disease; so that a work which he published on the practice of medicine, contains many facts and observations which are valuable, independent of their antiquity.

Averroes lived a little later than Avenzoar, and acquired from him his knowledge of medicine: he was a native of Corbuda, of respectable rank, and enjoyed every advantage of education. He did not follow the profession of physic, but was devoted to civil life, and by his talents and connexions arrived at the highest offices of the state. His liberal turn of mind conspired, with other circumstances, to excite some suspicions concerning the soundness of his religious creed, and he underwent on this account much severe persecution; but at length the obloquy of his antagonists was silenced, and he was reinstated in his honours and employments. Averroes was a man of distinguished virtues, although his character possessed too much of the ascetic cast; he was in a high degree temperate, patient, candid, industrious, and of spotless integrity. As a philosopher he was the obsequious follower of Aristotle, whose works he regarded almost with veneration; yet we are informed that he was ignorant of the Greek language, and that he had only an opportunity of perusing them through the medium of Arabic versions, which were incorrect and imperfect. He however published many comments upon them, which acquired a great degree of reputation, and were themselves the object of much attention for many centuries. His knowledge of medicine was that of a general scholar, rather than of a practitioner, yet he appears to have been much interested in the pursuit, and to have studied it with great assiduity. His attachment to Galen was no less devoted than to Aristotle; and in his great work, which treats of the general principles of the science, he regards him as the standard of medical knowledge, and the great point towards which his views are always directed. His superior rank, and the respectability of his character, seem to have acquired for his writings a much higher degree of credit than they are entitled to from their intrinsic merit. For several ages they were much read and admired, and a new edition of them was published so late as the beginning of the 17th century; at present, however, they are entirely neglected, and of all the boasted learning and philosophy of Averroes, it may be doubted whether any single trace now remains in the history of science.

The splendid reputation which the Saracenic school of medicine enjoyed is, no doubt, in some measure, to be ascribed to the effect of contrast. It sprung up among a people who had before been the declared enemies of learning, and who afterwards relapsed into their previous state of barbarism; while for some centuries, as well prior to this period as subsequent to it, the rest of the world was sunk in the repose of profound ignorance. Another circumstance also contributed to throw a factitious lustre upon these writers. When, in consequence of the intercourse which took place between Europe and Asia during the crusades, the literature of the Arabians was conveyed into Italy and France, it was through their medium that the philosophy and medicine of the Greeks were first made known to the inhabitants of these countries. Aristotle and Galen were read, either in Arabic translations, or in Latin versions taken from the Arabic, for a considerable time before the originals were discovered; and it is not improbable that had they not been, in the first instance, introduced to us through this channel, they might have remained unknown, and the few copies which were then deposited in the monasteries might have continued there neglected, and at length have been completely lost to the world.

The Saracenic physicians have, however, more direct claim upon the gratitude of posterity. Although, with respect to what concerns the theory of medicine and its general principles, they were the obsequious followers of Galen, and never dared to contradict his authority, yet we are indebted to them for some valuable additions in the different departments of the science. Several diseases of great importance were first discovered by Rhazes and his successors; they added a considerable number of new articles to the materia medica, and we entirely owe to them the introduction of chemical preparations into pharmacy. There is no subject in the whole range of medical inquiry more intricate and puzzling than what concerns the origin of new diseases, especially of such as are only propagated by contagion. Of these new diseases two of the most remarkable are, the small-pox and the measles. Every individual, with a few exceptions, is obnoxious to their influence, and although they do not affect every person with equal severity, yet their attack is independent of any peculiarity of age, constitution, or the habits of life; the old and the young, the most robust, as well as the most feeble, the African savage, and the civilized European, are their victims, in nearly an equal degree, while it is absolutely certain, that the diseases are never produced, except by the presence of a patient previously infected. The symptoms of these diseases are so distinctly marked, that it seems almost impossible that they could have existed among the nations of antiquity, and not to have been described by them, yet we are totally at a loss to imagine in what way they could have been produced in the first instance. As a point of historical fact, however, they seem to have been unknown to the Greeks and Romans; and the earliest account of them, which can be unequivocally recognized, appeared about the 9th century, in the writings of the Saracens. As the most easy method of solving this difficulty, it has been supposed that the small pox and measles, as well as some other of the most loathsome diseases, which are first mentioned by the writers of this period, had existed for an indefinite length of time in the remoter parts of Arabia, and perhaps also in other districts of Asia, which had very little connexion with the western parts of this continent or with Europe; and that they were first dispersed over the world by the followers of Mahomet, when they emerged from their native regions, and overwhelmed all the neighbouring countries with their destructive ravages.

It is probably from the local situation of the Arabians that we are indebted to their physicians for the introduction of many medical substances into practice, which were unknown to the ancients. Among these we may mention senna, rhubarb, tamarinds, cassia, and other aromatics, and various odoriferous gums and resins, which are indigenous on the banks of the Red Sea and the gulf of Persia, or were brought to their harbours from the Oriental Islands. But, important as were these additions, they are less so than the chemical remedies which form so essential a part of our pharmacopœias, and which were entirely unknown to the Grecian practitioners. It is generally supposed that the Egyptians were the original inventors of chemistry, or, at least, that some of the individual operations which we style chemical were employed by them at a very early period. In what way this knowledge passed from Egypt into Arabia, whether, as some have supposed, through the intervention of the Greek Ecclesiastics of the 5th and the 6th centuries, or whether it was more immediately transmitted by the proximity of situation, by conquest, or by commercial intercourse, is a point which it is not our business to discuss. But it is generally admitted, that Avicenna was one of the first writers who professedly published on chemical subjects, and who distinctly speaks of chemical remedies as articles commonly employed in practice. The immediate object indeed of the chemistry of this period is but little entitled to the appellation of philosophy, consisting principally of processes for the transmutation of metals, but in the prosecution of these researches, various substances were procured, of great utility in the arts of life, and constituting some of the most active pharmaceutical preparations.

After the extinction of the Saracenic school, in the 12th century, we arrive at a period of about 300 years, in which the whole world lay involved in the deepest gloom of ignorance. During this period there is scarcely a single object to attract the attention of the historian of science, and medicine shared the fate of every other department of learning. While the Arabic universities of Spain still maintained their reputation, some faint exertions were occasionally made in Italy and Greece; the school of Salernum acquired some celebrity in the 11th century, and at the same time, Constantine of Carthage, a man of erudition, published his works; but the sole individual who seems to be entitled to our notice as an actual improver of the science, is Mondino. He lived at Bologna in the 14th century, and, notwithstanding the complete state of degradation into which the human mind had fallen, he devoted himself with some success to the cultivation of anatomy; he even ventured to examine the structure of the body by dissection, and he published a system, which possessed a considerable degree of comparative excellence.

The only science, if it deserve that name, which was then pursued with ardour, was alchemy, a science well adapted to those dark ages of superstition. We may conclude, without hesitation, that many of its votaries were designing imposters; but when we consider the character of some who were engaged in it, and the immense labour which they bestowed upon it, we cannot doubt but that they were themselves the dupes of their own credulity, and that they expected to realize the promises which they held out of transmuting the baser metals into gold, and of obtaining a universal medicine, which should have the power of curing all diseases, and retarding the progress of old age. The visionary pursuits of the alchemists had, however, the incidental advantage of detaching mankind, in some measure, from their unbounded veneration for the ancients, and, amidst their numerous experiments, some discoveries were made that proved of real benefit to science, and laid the foundation of the more philosophical chemistry of their successors. During this period of darkness, while the human mind was slumbering in profound ignorance, the practice of medicine fell into its lowest state of degradation. It was chiefly exercised by the Ecclesiastics, or by those who were attached to the monastic orders; a class of men nearly as devoid of real knowledge as their contemporaries, but surpassing them in the arts of mysticism and imposture, as well as in the licentiousness of their conduct. By the use which they made of magic and astrology, and by employing the grossest superstition in aid of the defects of their medical skill, they obtained an influence over the minds of their patients which they frequently abused in the most infamous manner; and it may be asserted, that a great degree of positive mischief was effected by that profession, the sole object of which ought to be the alleviation of the evils necessarily incidental to humanity. A brighter prospect, however, soon opened itself to our view; and a reformation was at hand, which, not only in its immediate object, but in its ultimate effects, raised human nature to a higher elevation than it had obtained even in the most splendid periods of Greece and Rome.

CHAP. IV.

The Fourth Period, from the Revival of Letters to the middle of the 18th Century.

About the middle of the 15th century two events occurred, quite distinct in their nature, and totally independent of each other, but which conspired remarkably to rouse the energy of the human mind, by reviving the taste for learning and the spirit of philosophical inquiry; the destruction of the Byzantine empire by the Turks, and the invention of the art of printing. The Greek monasteries of Constantinople contained the only learned men who then existed; and when this city was captured by Mahomet the 2d, in the year 1453, they were expelled from their retreats, where they had long remained immured in solitude, and took refuge in Italy. They carried with them what they regarded as their most precious treasures, the copies of the ancient classical writers, which had existed in their libraries, unknown to the rest of the world, and valued by their possessors rather as objects of curiosity than as containing records of the arts and sciences, which were then no longer esteemed, or were even totally forgotten. The change of situation, however, and the new society to which they were introduced, tended to awaken their own minds to some degree of exertion, while their acquirements, limited as they were, excited the admiration of their new associates. The importance of the relics of ancient literature was quickly discovered, and diligent research was made for others of them which might still remain in existence. The singularly fortunate coincidence of the discovery of printing, with the dispersion of the Byzantine Greeks, produced the immediate multiplication of the treasures which had been thus brought to light; and the direct consequence of these events was the sudden progress of the intellect, from a state of the grossest ignorance to a high relish for literature, and a rapid advance in the knowledge of all the departments of science and philosophy. Another circumstance concurred with these two great events to complete the emancipation of the human mind. Various political intrigues tended to increase the intercourse between Italy and the other parts of Europe, and the papal authority was shaken, not only by the spread of knowledge among the people at large, but by disgust for the personal character of the individual who at that period filled the chair of St. Peter; and it yet remains a subject of controversy, whether the reformation was occasioned more by the voluptuous extravagance of Leo the Tenth, or by the enlightened spirit of Luther and his associates. After a severe struggle the cause of philosophy triumphed, and from this time the progress of knowledge and information has been invariably progressive, differing indeed in the rapidity of its advancement at different periods, but never relapsing into those retrograde movements, which, on former occasions, threatened to destroy all the labours of preceding ages.

The impulse that was thus given to the human mind first began to display its effects by producing a high respect for the writings of the Greeks, and a proportionate neglect of those of the Arabians. It was discovered that Avicenna, although purporting to be the implicit follower of Galen, had not unfrequently either mistaken or perverted his meaning, and many important truths were detected in the original, which had been totally obscured by the impure medium through which they had been hitherto conveyed. After Galen had been thus reinstated in that rank of public estimation which had been for some centuries usurped by his translators and commentators, Hippocrates next began to be read and admired. The simplicity of his principles was, however, less adapted to the genius of the age than the more complicated hypotheses of his successor, but there were not wanting individuals who were able fully to appreciate his merit; various editions of his works were published, and many learned men devoted themselves to their explanation. A custom began to prevail about this period, which tended very powerfully to assist in the advancement of medical science, the publication of collections of particular histories of disease and of individual cases. These were no doubt, in many instances, collected with little judgment, and narrated without much accuracy, exhibiting rather a fondness for the marvellous than a genuine love of truth; but they tended to foster a spirit of observation, and may in fact be regarded as the prime cause of the improved state to which medicine has been advanced in our own times.

One of the first of this description of writers, both in point of time and of ability, was Fernel, a native of France, who flourished in the early part of the 16th century. Although he was much attached to the ancients, and professed to make them the standard both of theory and of practice, yet he exhibited many marks of original genius, and has left behind sufficient proof that he was a diligent observer of the operations of nature. Nearly contemporary with him was Lommius, a native of Holland, whose works are still admired for the elegance and brevity with which they detail the phenomena of fever, and the treatment which was then adopted for its cure. Forestus, likewise a native of Holland, passed a long life in the unwearied pursuit of medical knowledge, the result of which he has recorded in a number of volumes, unwieldy from their bulk, and tedious from their prolixity, but containing the correct recital of a number of individual cases, and still regarded as a valuable repository of practical observations. About the same time lived Plater, who also spent a long life in the cultivation of medicine and all its collateral departments. He rose to the highest eminence in his profession, and for many years occupied the chair of medicine in the university of Basil, with great reputation. He was no less conversant with anatomy than with medicine, and he published many valuable works on both these topics, which still retain their importance, not only as forming a part of the history of science, but from their intrinsic excellence. A still higher degree of celebrity, if not of actual merit, was attained by Sennert, who practised at Wittemberg, in the early part of the 17th century, and whose works, consisting partly of a judicious selection from the ancients, and partly of original observations, made in the course of a very extensive practice, were long regarded as the standards of medical knowledge, and are still considered as exhibiting a valuable picture of the state of medicine at the time when he wrote. The authority of Galen is always appealed to by these authors with the most implicit respect, and although it was now allowed that additions might be advantageously made to his writings, yet it was very rarely that any one ventured to oppose his principles, or controvert any material part of his practice.

But a revolution in public opinion was now impending, by which the unbounded veneration for the ancients was to be destroyed, and our attachment to them reduced within its just limits. This was accomplished by the labours of two descriptions of men, totally different in their characters and the nature of their pursuits, but who incidentally conspired to bring about the same ultimate effect—the chemists and the anatomists. We have already alluded to the labours of the alchemists during the ages which immediately preceded the revival of letters, and this event seems, at least for some time, rather to have promoted than to have checked their ardour. It was about this period that an attempt was made to connect the science of chemistry with that of medicine, and many individuals united the two pursuits; but of these the first, in point of celebrity, was Paracelsus, a native of Switzerland, who flourished at the commencement of the 16th century. From his vanity and presumption, more than from his talents and acquirements, he obtained, for a short time, a singular degree of popularity. His great object was to undermine the authority of the

Galenic school, and to substitute in its place the chemical doctrines, to accomplish which purpose he employed all the arts of the most bare-faced quackery. He publicly burned the works of Galen and Avicenna, as no longer of any value, proclaiming that they were entirely superseded by his discoveries; and he boldly promised uninterrupted health and longevity to those who would take his elixir and obey his precepts. His own death, which happened at an early age, gave the first shock to his reputation; but although, by this event, his character was reduced to its real standard, yet, together with all his absurdities, he had promulgated some important truths, which made a lasting impression upon the state of medical opinions.

The leading tenets of Paracelsus's theory were, that living organized bodies not only consist of the same chemical elements with all other kinds of matter, but that they are subject to the same chemical actions, and are not governed by any laws peculiar to themselves. The chemical elements he supposed to be three, to which he gave the denominations of sulphur, mercury, and salts; upon the proper proportions of these he supposed the healthy state of the body to depend, and from their excess or defect that its various diseases originated. These elements are, in the first instance, conveyed into the blood by the food, which essentially consists of the same principles; and it is supposed that the stomach is provided with an intelligent agent, which presides over its operations, enables it to separate the nutritive from the noxious particles, and thus to repair the loss of the system. Besides this prime agent, or archeus, as it is styled, which directs the actions of the digestive organs, there are other agents or powers, five in number, to which particular offices are allotted, and to which he assigned the fanciful names of *ens astrorum*, *ens veneni*, *ens spirituale*, *ens naturale*, and *ens dei*. From the operation of these powers a great variety of chemical changes are perpetually going forwards in all parts of the body; and different species of sulphur, mercury, and salts, are composed and decomposed, according to the wants of the respective organs. (Barchusen, *diss.* 19.) But it is unnecessary to dwell longer upon this mass of absurdity, no less complicated and remote from the truth than the elements and qualities of Galen, which had been held up by the chemists as the subject of their supreme contempt and ridicule. Wild and unfounded, however, as were the speculations of Paracelsus, they led him to introduce into practice some chemical remedies of great efficacy, which, in the hands of his successors, have proved among the most valuable articles of the materia medica. The pharmaceutical preparations of the ancients were taken almost entirely from the vegetable kingdom; and, although some metallic substances were employed by the Arabians, when they first turned their attention to chemistry, yet we are indebted for the greatest number of them to the alchemists of the 15th and 16th centuries.

After the death of Paracelsus, his peculiar theory fell into oblivion, but the application of chemistry to the explanation of the phenomena of disease continued to be a favourite pursuit with many of the most learned men of the 16th and 17th centuries, and produced various speculations and hypotheses, which will demand some share of our attention. Nearly allied to the mystical opinions of the earlier chemists, were the still more fallacious doctrines of magic and astrology, which, long after the revival of letters, still continued to form a part of the popular creed, and even not unfrequently to possess a considerable degree of power over the minds of men of learning and reflection. The belief in the influence of the heavenly bodies, and in the operations of demons and supernatural agents of various kinds, was indeed almost universal, and so firmly rivetted was it in the minds of the multitude, and so connected with the theological doctrines of the period, that even those who were convinced of the delusion scarcely dared to expose themselves to the obloquy which must have inevitably followed from the avowal of their scepticism. Still, however, in spite of these obstacles, the progress of information was not altogether impeded, and, notwithstanding all the errors which still adhered to it, the knowledge of medicine was in a state of improvement.

To this advance nothing contributed more essentially than the discoveries of the anatomists, which commenced about the middle of the 16th century. The knowledge which Galen possessed of the structure of the body was very extensive, and when we reflect upon the circumstance, that human dissections were not permitted in his age, we have more reason to admire the correctness to which he attained, than to censure him for the errors which he committed. For about 1200 years after his death, not a single improvement was made in anatomy, and his authority on this subject was regarded as quite incontrovertible, when Vesalius, taking advantage of the general spirit of inquiry which now began to prevail, undertook to investigate the structure of the human body, and, in consequence of his own observations, felt himself warranted in questioning some of Galen's descriptions. It does not fall under our immediate object to trace the progress of anatomical discovery, or to relate the various and acrimonious disputes which occurred, before the admirers of the ancients would consent to give up any part of their respect for Galen, or to admit the possibility of his having fallen into any errors.

Eustachius became his zealous defender, and warmly opposed Vesalius; but, nothwithstanding his support, and that of many other learned men, the truth gradually prevailed, and it was at length agreed that the anatomy of the ancients was in many points incorrect, and that Galen in particular had seldom, if ever, examined the human body, but in its stead had employed apes and baboons. It does not appear that the discoveries of the anatomists had any direct effect in improving the practice of medicine, or in purifying it from any of its grosser errors, but they powerfully conspired, with the labours of the chemists, in diminishing the veneration for the ancients; and they completely established the point that Galen was not infallible, and that although his knowledge was probably greater than that of any other individual, at the time when he lived, yet that there was still much left to be accomplished by his successors.

Another circumstance, which indirectly tended to the improvement of medicine, was the gradual downfal of the scholastic philosophy of Aristotle, which, until this period, had continued to exercise an absolute authority over every department of physical science. It is well known that the illustrious Bacon first distinctly pointed out the true method of proceeding in the investigation of truth; the spirit of the age seconded his exertions, so that, although the absolute additions which he made to our knowledge were not considerable, yet the effect which he produced was of the first importance, and to him we must consider ourselves as indebted for a large portion of all the information that has been acquired by his successors. In connexion with Bacon, and as one who powerfully contributed to the same general result, with respect to the state of philosophical opinion, we may place Descartes, a man of a different turn of mind, and devoting himself to a different train of pursuits. He was not endowed with the sagacity of Bacon in discerning the correct method of acquiring knowledge, nor in guiding the progress of philosophical inquiry into its legitimate channel; but he perceived the fallacy of the Aristotelian mode of reasoning, and by his boldness in investigating the operations of nature, and the ardour which he displayed in the prosecution of science, he excited a degree of attention, which perhaps eventually proved no less effective than the more prudent and cautious proceeding of Bacon. While this reformation was thus advancing, its progress was aided by the improvements which were made, from time to time, in the various medical schools of the different countries of Europe. Italy, from its situation as the original seat of the revival of letters, led the way in this career; it extended itself into France and Holland, afterwards into some parts of Germany, and lastly into England; but, partly from its situation, and partly, perhaps, from the public mind being more occupied by the contests of theology and politics, the progress of medical knowledge in this island did not keep pace with that of the principal nations of the continent.

During this period, from the revival of letters to the commencement of the 17th century, the medical world was divided into the two sects of the Galenists and the chemists. The former included most of the men of learning and of scientific education, the professors of the universities, and what may be styled the more regular practitioners. They chiefly employed themselves in collecting observations and recording medical histories, but always adhering as much as possible to the doctrines of their master, and endeavouring to reconcile every phenomenon to his tenets. Their practice was complicated, and often inert; their prescriptions were principally composed of vegetable preparations, great numbers of which were combined together in the most incongruous and unscientific manner, so that it is extremely difficult to conjecture what effect could have been produced by any of their most celebrated recipes. The chemists, in their general views and character, differed in almost every respect from the Galenists. They were men rather of genius than of erudition; in the first instance, they were many of them irregular practitioners, who had not been originally brought up to the profession of medicine, but who entered upon it in consequence of some supposed discovery of the nature of disease, or the action of certain remedies, and perhaps not unfrequently from some more unworthy motive. Their practice was directly opposed to that of their rivals. They employed only a few medicines, but those of the most powerful kind; they rejected all complicated formulæ, discarded a great proportion of the articles of the materia medica, and substituted, in their room, the metallic preparations, retaining only a few of the most active vegetable substances. The general result of the proceeding of these two opposite sects is not very different from what might have been predicted; for we learn, from the mutual accusations which they brought against each other, and which we may regard as founded in truth, that the practice of the Galenists was frequently futile, while the chemists, although they might occasionally perform remarkable cures, as often committed fatal mistakes. The chemists seem, however, to have gained in the public estimation upon their rivals, partly from their success in individual cases, and from the greater apparent efficacy of their practice, and partly from their more lofty pretensions, and from the arts of popularity which they assiduously cultivated. While they were thus acquiring a greater share of the public respect, they gradually became more worthy of it: the mysticism of Paracelsus was now generally ridiculed; the pursuits of alchemy were going out of fashion; and there were few men of education or respectability who openly professed their belief in the existence of the universal medicine. The sect of the chemical physicians began to assume a more scientific form; it was embraced by men of learning and character; and, in consequence of their being less fettered by authority, and more disposed to gain new information from all quarters, they continued to rise in the public opinion, while the adherents of the old doctrines were proportionably neglected.

The refinement of the chemical medicine was so gradual an operation, that it is impossible to ascribe the merit of it to any single individual; but those who are generally considered as its most able and learned defenders, and in whose writings the theory is exhibited in the most correct form, are Sylvius and Willis. Sylvius was born in Flanders, in the beginning of the 17th century. After studying in various universities, he settled for some years at Amsterdam, where he rose to great eminence as a practitioner, and finally became the professor of medicine at Leyden. He was distinguished as an eloquent lecturer; and, from this cause, as well as from his learning and genius generally, he attracted a large audience, and gave a proportionably extensive circulation to his peculiar hypotheses. He derived all the operations of the animal body, both in its state of health and disease, from a chemical condition of the fluids, which produced effects analogous to fermentation. Some of the secretions, particularly those connected with the digestive organs, were supposed to be naturally acid, while the bile was naturally alkaline; and according as one or other of these predominated, a certain train of morbid symptoms ensued. An important part of the theory was, that acute febrile diseases depended upon the acid state of the humours, and were consequently to be cured by alkalies; and, in conformity with the usual custom of theorists, who always find those practices to be successful which favour their own speculations, he discovered that alkaline medicines were the specific remedies for fever. Sylvius's hypothesis of fermentation, with its acids and alkalies, soon became the prevailing doctrine among the German and French physicians, and had many strenuous adherents in this country, of whom the most learned and respectable was Willis.

We are told that Willis, early in life, exhibited a fondness for the study of chemistry; and it appears that it was principally from his proficiency in this science that he obtained the honour of being one of the original members of the Royal Society. He first appeared as an author in the year 1659, when he published his treatise on fermentation and on fever; the object of which is, to show that all the natural actions of the body are brought about by certain specific fermentations, and that diseases proceed from the irregularity of these fermentative processes. There is in these essays a considerable share of what may be called genius, and at that period, when strict induction was not regarded so essential as it is at present, we may conceive that they would be greatly admired. Willis has, however, much more claim upon the gratitude of posterity, than for the mere formation of ingenious hypotheses. He was a correct observer of the phenomena of disease, and detailed them with characteristic acuteness; he was also a good anatomist, and particularly directed his investigations to the brain, the different parts of which he accurately described, while, at the same time, he broached some original and curious opinions respecting the action of the different parts of the nervous system, and its connexion with pathology. The works of Willis are still read with advantage, although it is probable that those parts which rendered them the most popular at the time of their publication, are what we now regard as useless incumbrances, and tolerate only in consequence of the valuable matter to which they are attached.

The fame of Willis, although considerable, has been partially obscured by the still greater celebrity of his contemporary and countryman Sydenham. This distinguished physician was a native of the county of Dorset, studied at Oxford, and commenced practice in London about the middle of the 17th century, where for some years he enjoyed a large share of the public confidence. Sydenham has been styled the English Hippocrates; and there is a great resemblance between their scientific and intellectual characters. Although they were both of them theorists, and, on many occasions, apparently founded their practice upon their theories, yet they were still more attentive to the observation of facts, and they seldom permitted their speculative views of the nature of a disease to interfere with those circumstances which contributed to the welfare of their patients. Like all the other pathologists at that period, he was a humoralist, and he attributed the changes which the fluids experienced to some chemical process, generally of the fermentative kind; yet, in opposition to Willis, and others of that age, he directed his prime attention to the observation of the phenomena of disease, and rather employed hypothesis as the mere vehicle by which he conveyed his ideas, than as what, in any respect, tended to influence his judgment respecting either the cause of the morbid changes of the body, or the means of removing them. His general notions respecting the nature of disease were very similar to those of Hippocrates, that it consists in an effort of nature to remove some morbid cause; and, according to the rapidity with which the process is effected, diseases are divided into the two classes of acute and chronic. The object of the practitioner is to bring the disease to its proper crisis, in some instances to moderate the violence of the operations of nature, and in others to assist them; an hypothesis in itself, no doubt, as fanciful as that of the Galenists, or the professed chemists. It however possessed the great advantage of leading the practitioner to watch narrowly over the progress of the disease, and to employ a mode of treatment, which, although it might be styled temporizing, is in fact well adapted to the state of medical knowledge; consisting of the due mixture of theory and experience, in which seems to consist the perfection of our art. Among the direct practical improvements for which we are indebted to Sydenham, is the employment of the antiphlogistic treatment in small-pox, at that time one of the most fatal epidemics; an improvement which appears to have been partly suggested by reasoning upon the nature of the disease, but which, however originally introduced, has been amply sanctioned by experience. The merit of Sydenham has been justly appreciated by posterity, both in his own country, and among foreigners; his works continue, to this day, to be a standard authority; and, what is extremely rare with respect to any of the modern physicians, they are as much esteemed after a lapse of a century and a half, as they were immediately after their publication.

But, notwithstanding all the personal respect which he obtained, and the estimation in which his works were held, it does not appear that Sydenham made any powerful impression upon the general state of medicine, or that, in any material degree, he diverted the current of public opinion from its former channel. This may be attributed to several causes. In the first place, the state of science, and especially of medical science, was not ripe for that revolution which might otherwise have been produced by the efforts of such an individual. Although Bacon had published his *organon* some years before, and although, in the various parts of Europe, the spirit of research was rapidly advancing, yet hitherto medicine had not felt much of its salutary influence; and mankind were not aware that it did not essentially differ in its principles from the other branches of natural philosophy, but that, like them, it must be founded upon observation and experience. It must also be admitted, that even Sydenham was only a partial reformer, and was probably not himself thoroughly sensible of the great truth, that all abstract reasoning, not deduced from the generalization of facts, is in itself equally objectionable. So far from discarding hypothesis, it apparently lies at the foundation of every part of his system; and if his discrimination led him to place it in subjection to experience, this is done rather, as it were incidentally, than as a matter of general principle. But perhaps the most powerful cause which operated to prevent the full effect which might have been expected to ensue from the example of Sydenham, was the invention of a new theory of medicine, more captivating than any which had hitherto appeared, and which, for some time, obtained more firm possession of the mind, than any which had appeared since the time of Galen. We refer to the mathematical sect.

The mathematical physicians first appeared in Italy, and the honour of having given birth to the new hypothesis, may be attributed more to Borelli than to any other individual. Some circumstances occurred about this time which prepared the minds of the public for its reception. Among these we may mention, in the first place, the very great advances which had been made in astronomy, and in other departments of natural philosophy, by the aid of mathematical reasoning, and the popularity which all these pursuits hence acquired. In the same proportion as mathematical knowledge advanced, chemistry became neglected; and for a century after this period, it can scarcely be said to have attracted the attention of a single individual of learning and genius. It has been supposed, and apparently with reason, that the discovery of the circulation of the blood, which had been just completed by the celebrated Harvey, and the knowledge which was thus obtained of the mechanism of the heart, tended to dispose medical men to apply mechanical explanations to all the operations of the living body. The same effect would be still more directly produced by the publication of Borelli's treatise, in which he explains all muscular motion by a series of mathematical propositions; a work which displays considerable ingenuity, and many parts of which are founded upon correct principles. After this successful application of mathematical reasoning to the action of the muscles, he proceeds, although with less success, to employ it in examining some of the other functions; but Bellini seems to have been the first physiologist who adopted it as a general proposition, that all the operations of the body might be reduced to mathematical principles.

Bellini was born at Florence, in the middle of the 17th century. He exhibited early marks of talent, and, while quite a young man, commenced his career as a public teacher. His abilities were perhaps rather splendid than solid, more adapted to captivate the fancy of a youthful audience, than to convince the sober judgment of his readers; so that when we now peruse his works, we cannot but feel some surprize at the reputation which they formerly enjoyed. Influenced, as we may suppose, by the success which had attended the efforts of Harvey and Borelli, Bellini resolved to extend to every part of the body the mechanical theory which they had applied to the heart and the muscles; and he assumed the general principle, that the living system, in all its operations and functions, is strictly obedient to the laws of gravity, and that the same reasoning may be used concerning it, as we employ in the explanation of the phenomena of hydrostatics and hydraulics. The converts to this new hypothesis immediately became very numerous; and both in physiology and pathology, nothing was heard of but calculations respecting the size of the particles, the diameter of the pores and vessels, the friction of bodies against each other, the impulse of the fluids, their derivation and revulsion, the momentum of the blood, its viscidity or lentor, its obstruction or resolution, and various other hypothetical expressions, all of them directly or indirectly derived from a mechanical cause, and regarded as the sole agents in every corporeal action. To enumerate all the celebrated names that were attached to this hypothesis, or who supported it by their arguments, would be to mention every writer of eminence that appeared either in Italy or in England. By the French and Germans, the mechanical medicine was less generally adopted, although there were not wanting some individuals among them who embraced it, and carried it to its greatest extent; yet many of the former still remained attached to the chemical doctrines; while the latter were, for the most part, more disposed to accumulate observations, or to write comments upon the ancients, than to form new hypotheses, or even to embrace them after they had been formed by others. It would be neither interesting nor instructive to examine the works of all the mechanical physicians, or to state the different additions or modifications which they made in the theory. Their leading principles were, in all cases, exactly similar; and, as a great part of their applications of them were without foundation, it is not necessary to spend our time in relating opinions, which, however they may have been admired at the time, are now universally allowed to have been fallacious. We shall, however, give a brief account of some of the most celebrated men of this sect; for, as forming a part of the history of medical science, it would be improper to pass over a number of individuals, who were certainly among the most learned of their age, and who, if they did not make any actual addition to the knowledge of medicine, yet they indirectly tended to raise the credit of their profession by their acquirements and abilities, and prepared the way for the improvements of their successors. In this sketch we shall confine ourselves to the authors whose fame rests upon their medical writings, omitting those who are only known to posterity as anatomists or physiologists; a principle of selection which is obviously necessary to our object, although it may lead to the exclusion of some of the most celebrated names in our profession. The application of mathematics to physiology was indeed more successful than to pathology or to medicine; although many of the calculations were grossly erroneous, a circumstance which is clearly proved by their discordance with each other; yet it must be admitted, that some important truths were gained by the employment of mathematical reasoning in the explanation of the animal functions, which perhaps would not have been obtained by any other means, while it may be questioned, whether any single improvement, which can properly be styled medical, is to be attributed to this cause.

Although the countrymen of Bellini seem generally to have adopted his hypothesis, yet, with the exception of Baglivi, who will more properly come under our notice in a subsequent part of the history, their posthumous reputation depends principally upon their eminence in the collateral departments of the science. In England, the mechanical doctrine was applied more immediately to pathology and to therapeutics, and was adapted not only to the individual effects of diseases, but to explain the action of particular remedies upon them. One of its first and most zealous defenders was Pitcairne, a native of Edinburgh, but whose celebrity was so considerable, as to have obtained for him the professorship of medicine at Leyden, a situation which he filled for some time with great reputation. He was a correspondent of Bellini, embraced his doctrines in their fullest extent, and made them the basis of his speculations. The confidence with which he maintains his opinions, now that we know them to have been entirely fallacious, is not a little amusing, and should operate as an example to all theorists, of the futility of the most ingenious efforts of the intellect, when not directed into the proper channel. He published little, but what he wrote seems to have been carefully studied; and his "physico-mathematical elements of medicine" was long regarded as a standard work, and may still be considered as giving one of the best abstracts of the system.

Few physicians of modern times have arrived at greater local celebrity, or have passed a longer life in the uninterrupted enjoyment of professional honours, than Mead. He was born in the neighbourhood of London, towards the conclusion of the 17th century, was educated in the first medical schools of the age, and, among other learned men under whom he studied, became the pupil of Pitcairne, and imbibed from him the mechanical hypothesis. His writings are not very numerous, nor do they display either brilliant genius, or deep erudition; but they are written in an elegant and perspicuous style, and indicate a familiarity with the usual topics by which this theory was illustrated and supported. A considerable share of Mead's popularity may be attributed to his personal address as a practitioner, to the honourable line of conduct which he uniformly adopted towards all the members of his profession, and perhaps, in some measure, to a variety of accidental circumstances, which brought him early into public notice. Contemporary with Mead, was Friend, a man of greater talents and learning, who also adopted the mechanical system of medicine, and defended it with more zeal, in proportion to the greater warmth of his disposition, and the more lively interest which he took in scientific discussions. He was a native of Northamptonshire, received his education at Oxford, where he distinguished himself by his classical acquirements, and finally settled in the metropolis. He died at the age of 53, a circumstance which, together with his becoming involved in political contests, as well as his engaging in some angry professional disputes, probably prevented him from gaining an equal share of reputation and practice with his rival Dr. Mead, to whom he must be considered as decidedly superior, both in his intellectual qualities and his literary attainments. The work by which he is best known to posterity, and which fully supports its credit to the present day, is a history of medicine, from the death of Galen to the revival of letters, in which he gives a very perspicuous account of the writings and opinions of the physicians who flourished during this period; it is particularly valued for the information which it contains respecting the Saracens, and on this subject is referred to as a standard publication. His style, both in Latin and English, is much admired for its correctness and classical brevity; and, upon the whole, there are few among our countrymen, who have united, in a higher degree, the characters of the physician and the man of letters.

While the chemical and mathematical sects were thus dividing the opinions of the most learned men of the age, a new doctrine was gradually rising up, which, although in its origin it was equally if not more remote from the principles of true science, yet, after having passed through a number of successive purifications, it at length appeared in a more correct form, and occasioned the complete overthrow of both the contending parties. The first defender of the chemical principles of Paracelsus, who is entitled to the character of a man of science, is Vanhelmont. He was born at Brussels, towards the conclusion of the 16th century; he entered upon the study of medicine with diligence and ardour, and, at an early age, acquired a disgust for the scholastic method of teaching, then adopted in the universities; which he extended to the doctrines of the ancient physicians, and especially to those of Galen, whose authority it was afterwards the object of his writings to overthrow. He warmly recommended the bolder practice, and more efficacious remedies of the chemists; but he adopted, as an essential part of his hypothesis, the idea, that all the changes which are perpetually going forwards in the body, constituting both its healthy and its morbid actions, are under the influence of a superintending principle, which he styled the *archeus*; thus borrowing from his master this whimsical appellation, and in some respects also the rude outlines of his theory. Vanhelmont was a man of a bold and enterprizing genius, better adapted for discarding a false hypothesis, than for establishing a more correct one in its room. He was credulous and superstitious, little accurate in his observation of phenomena, and little discriminative in his selection of facts; so that, although he contributed powerfully to shake the confidence of his contemporaries in the dogmas of the ancients, he procured for himself no followers of any considerable reputation. His metaphysical notions concerning the operations of the *archeus* were but little attended to, and made scarcely any impression upon the general state of public opinion; when, after a lapse of about a century, a very distinguished genius arose, who, taking them as the basis of his reasoning, moulded them into an hypothesis, which acquired a great degree of celebrity, much of which it has retained even to the present day.

Stahl, the individual to whom we refer, was a native of Franconia, and passed the principal part of his literary life as professor of medicine in the university of Halle. It was a distinguishing trait of his character, to form his opinions for himself, and to be but little influenced by those of others; accordingly, the first efforts of his mind seem to have been directed to the subversion of the hypotheses of his contemporaries. He was brought up in the school of the chemists; but he soon became aware of the futility of their pathological doctrines, and perceived numerous instances, where the changes which the fluids undergo in the body were completely unlike what they would have experienced, if placed in ordinary circumstances. It is well known, that substances similar to those which constitute the body, rapidly tend to a state of putrefaction and dissolution; and he therefore concluded, that when forming part of the living system, they must be possessed of some additional principle, which counteracts the effects that would otherwise have been produced. To the agent which thus acts in opposition to the physical powers of matter, and to which the body owes all those properties that are strictly denominated vital, he gave the name of *anima*; he conceived it to possess peculiar qualities, distinct from those which belong to matter; and he especially endowed it with a species of intelligence, or even consciousness, by which it acts the part of a rational agent, and, like the *archeus* of Vanhelmont, is the general director of all the corporeal operations.

This doctrine of Stahl was probably derived, in the first instance, from the principles of the Cartesians, then in the height of their reputation, according to which, matter is to be regarded as entirely passive or inert, and indebted for all its active properties to the addition of an immaterial animating spirit. All the operations of the body, both physiological and pathological, were regarded by him as resulting from the reciprocal action of the general properties of matter upon those which exclusively belong to the living system; a mode of viewing the subject which is certainly correct. He had also the merit of clearly perceiving, that the phenomena of life could not be referred to the action either of chemistry or of mechanics, a truth which is incontrovertible, and which, simple and obvious as it now appears, had been overlooked or disregarded by the most learned or acute of his predecessors. But, after having thus established a firm basis for his hypothesis, he was led astray by the fashionable metaphysics of the times; and, instead of investigating the nature of the animal functions, ascertaining the laws which direct them, and pointing out the circumstances in which they differ from those of inanimate matter, he thought it sufficient to refer them all to an hypothetical principle which he assumed, and invested with powers exactly accommodated to his purpose. In its general aspect and character, the *anima* of Stahl very much resembles the *φυσις*, or *nature*, of Hippocrates; but there is this essential difference between them, that Hippocrates proposes merely to offer an expression of the facts that are observed in the animal economy; whereas Stahl, especially when he descends to minute detail, speaks of this hypothetical principle as something distinct from the body, and superadded to it, which actually produces its powers and faculties, and enables us to explain the nature of its operations. Among the particular pathological opinions of Stahl, one of the most important was, that the body has a constant tendency to the plethoric state, and that it is the office of the intelligent principle to prevent the bad effects of this plethora by producing the necessary evacuations. This led to the grand practical deduction, that a great part of the duty of the physician is to regulate the state of the evacuations, to promote them if too scanty, or to check them if too profuse. It must be admitted that the Stahlian hypothesis was of essential use to the science of medicine, by directing the attention to the vital actions of the body, and by completely overthrowing all those systems which pretended to explain the animal functions by the physical laws of matter. But, on the other hand, it had the unfavourable effect of diverting the mind from the researches of anatomy, and the actual observation of disease, and attaching it more to the subtilties of metaphysics. As it is more easy to theorize than to acquire real knowledge, the hypothesis was received with much applause, and obtained some zealous supporters of considerable learning and ability; but the period when Stahl flourished was less favourable to the spread of any theory, however alluring its aspect, than the ages which had preceded it. The necessity for patiently investigating the operations of nature, and deducing our first principles from the generalization of facts, was better understood, and more attended to; while the spirit of inquiry was so widely diffused as to produce a variety of rival hypotheses, which thus tended to prevent the universal adoption of any one of them in exclusion to the rest. Although, therefore, the Stahlian doctrine had a very considerable influence in producing a revolution in medical opinion, and although, under various modifications, it may be traced in the language of many of the most distinguished writers, even to the present day, yet the number was not large of those who implicitly adopted its tenets in their full extent.

While the mechanical systems of medicine were thus powerfully assailed by the metaphysical theory of Stahl, a less direct, although not less effectual attack was made upon them from another quarter, and one which eventually produced an equally great revolution in the science. Until this period, all the theorists, whether Galenists, chemists, mechanicians, or metaphysicians, were attached to the doctrines of the humoral pathology. They conceived all the changes which took place in the body, to consist in an alteration in the state of the fluids, and that, if any effect was produced upon the solids, it was only secondary or consequential to the former. Whether, according to the doctrine of Hippocrates and Galen, which was embraced, under various modifications, by the ancient physicians, and by those of the middle ages, these changes depended upon an excess or defect of any of the four humours or qualities; or whether, according to the hypothesis of Sylvius, the fluids became acid or alkaline, or entered into the fermentative or putrefactive state; whether, according to the mathematicians, they differed from each other in consequence of some alteration in the size, shape, or gravity of their particles; or whether, rejecting all these ideas, and considering less the nature of the effect, than the manner in which it is produced, we attribute the changes to the agency of an immaterial superintending principle, still the fluids were the media through which they were brought about, and were the parts which were supposed to be originally affected.

It would appear that the first clear conception of the contrary opinion was formed by Baglivi, who was born towards the conclusion of the 17th century. He acquired so high a reputation for his assiduity in the pursuit of medical science, and the sagacity with which he viewed the operations of the animal economy, that he became professor of anatomy at Rome, and was proceeding in his literary career with great success, when he died prematurely, at an early age. He was a warm defender of the Hippocratean method of describing the phenomena of diseases; but he rejected the opinion that they originated from any altered state of the humours, and conceived that the morbid changes commenced in the solids, or, as he expressly designated them, in the moving fibres, and that these, by their action, operated upon the fluids, and gave them their peculiar properties. His account of the moving fibres is not without its objections; but from the specimen which he has left of his talents, it may be presumed that, had his life been prolonged, he would have reduced his hypothesis into a more correct form. With all its imperfections, however, it may be regarded as a prime cause of the revolution which afterwards took place in this part of medical science, and as having directly led to the more successful speculations of his successors.

During this revolution, by which the old systems and speculations were yielding to the new doctrines, the inductive philosophy, which had for some time been adopted in various branches of science, was gradually extending itself to the study of the animal economy. Many circumstances tended to retard the progress of this department of knowledge, and caused it to be one of the last which felt the benefit of the modern improvements. But the most important of these, and what may be considered as equivalent to all the rest, is the difficulty of ascertaining what are the powers and faculties that exclusively belong to the living body, and in what respect they differ from those that are attached to inanimate matter. Stahl had decidedly stated, that the operations of chemistry and mechanics were unable to account for the vital functions, and had adduced arguments to prove his position, which seemed to be incontrovertible; yet the hypothesis which he substituted in place of the former was equally gratuitous, and liable to at least an equal weight of objections. His speculations had, however, the effect of turning the attention more immediately to the investigation of the phenomena directly connected with life, and especially assisted in tracing their connexion with the other operations of nature, and in ascertaining more correctly the laws by which they were respectively governed. This process was attended with much difficulty, and the advances which were made in it were very gradual; but it must be considered as the legitimate plan of proceeding, and that which will eventually lead to the true theory of animal life, and to the just principles of pathology.

When knowledge is acquired by slow degrees, and the truth is only elicited after many repeated and unsuccessful efforts, it is not easy to assign to each individual the exact share in which he contributed to the progress of improvement, or to ascertain precisely in what proportion his exertions may have conspired to the final result. In the present instance, we are disposed to allow a considerable degree of merit to Hoffmann, who, although a hasty and multifarious, rather than an accurate and consistent writer, was among the first who took a correct view of the subject of pathology. He was born in Saxony, about the middle of the 17th century, and was descended from a family which had long distinguished themselves for their medical knowledge. Upon the establishment of the university at Halle, he was nominated professor of medicine, and Stahl was appointed his colleague. He was very diligent in the exercise of his office, and assiduously fostered the spirit of free inquiry among his pupils, so as to raise the credit of the college to a high pitch of reputation, while he, from time to time, increased his own fame by his numerous publications, and especially by his great practical treatise, *The System of rational Medicine*. Hoffmann's collected works occupy no less than six folio volumes, which it must be supposed contain many repetitions, and a great mass of what is of inferior value; yet the judgment of posterity has admitted, that they also contain a considerable portion of interesting facts and observations, and, notwithstanding their redundancies, they have taken their station among the most esteemed of the medical classics.

But the fame of Hoffmann depends less upon his acuteness as a practitioner, or his accuracy as an observer of the phenomena of disease, than upon his ingenuity as a pathological theorist. He embraced the opinion of Baglivi, and laid it down as the basis of his speculations, that the cause of disease may be more easily traced to some affection of the solids, than to any alteration in the state of the fluids: but he proceeded farther, and endeavoured to explain the nature of this affection, by introducing the operation of what he called spasm and atony. According to this celebrated hypothesis, the moving fibre is indued with a certain degree of action or tone, which constitutes its healthy state; but, from various circumstances, this action may be morbidly increased on the one hand, so as to generate spasm, or morbidly diminished, until it arrives at the opposite condition of atony. This theory, in the outline, may be thought to resemble the constricted and relaxed fibre of the ancients, although, from the various modifications which were introduced into it by Hoffmann, it acquired so novel an aspect as to entitle it to the merit of originality. But perhaps a still more important part of his doctrine was, the use that he made of the action of the nervous system, which, as a general principle, had before been little attended to, but which he supposed to be intimately connected with the production of disease. It would be difficult to enter into a minute detail of the several parts of Hoffmann's pathology; for, in consequence of the number of his writings, and probably the hasty manner in which they were composed, he has not always strictly adhered to his own principles. Besides, it may be presumed, that his views of the animal economy experienced considerable alteration, and were gradually matured as he advanced in life; yet he never gave them in that abstracted or concentrated form, which can enable us to ascertain what parts he ultimately considered as the most essential, or which of his earlier opinions he afterwards rejected.

Contemporary with Stahl and Hoffmann was Boerhaave, a man perhaps equal to either of them in the general powers of his mind, and superior in learning and information. If he exhibited fewer marks of genius and originality, he possessed more judgment; and there are few individuals whose intellectual and moral qualities were more correctly balanced, so as to produce a character the best fitted for the station which he occupied in society. He was born at Leyden, and was brought up to the church; but owing to some circumstances, which threw a suspicion on the soundness of his theological tenets, he was fortunately induced to turn his attention to the study of medicine. He devoted himself, with the utmost assiduity, not only to the acquisition of practical knowledge, but to every department connected with the science; and his acquaintance with chemistry and botany was so considerable, as to enable him to lecture on these subjects with the highest reputation. Although he received many flattering offers of patronage from various quarters, he preferred remaining in the university of his native town, which, by his exertions, he raised to be the first medical school in Europe. No one ever enjoyed greater fame as a teacher; and from this circumstance, as well as from their intrinsic merit, his doctrines acquired a degree of ascendancy over the public mind, which has scarcely been attained since the time of Galen. Making due allowance for the difference necessarily resulting from the state of science, we may trace a considerable resemblance between the scientific characters of Galen and Boerhaave. We find the same extensive range of knowledge, on all topics directly or indirectly connected with medicine; the same facility in applying their knowledge to the explanation of the principles of pathology; the same dexterity in availing themselves of the information of their predecessors or contemporaries; and the same power of extracting what was valuable from the systems of others, combining and modifying the separate parts, and moulding the materials into one consistent and harmonious whole. Had Boerhaave lived at a period when the progress of the human mind was less rapid, and when a spirit of inquiry and of philosophical research was unknown, it is probable that the influence of his opinions might have been as extensive and as durable as those of Galen. But the genius of the age was not favourable for the support of any hypothesis, however interesting in its outline, or beautiful in its separate parts; and unfortunately Boerhaave adopted, as the basis of his theory, a number of speculative principles, which might suffice for explaining the phenomena, but which were themselves derived from conjecture, and deficient in proof. Although, therefore, the Boerhaavian system obtained the highest celebrity during the lifetime of its inventor, and has ultimately exercised a very considerable power over medical opinion, yet the number of those who implicitly adopted it was not great, and while it promoted the detection of preceding errors, it produced a state of mind which led to its own downfall.

The object of Boerhaave, in the formation of his system, was to select the most important parts from all preceding systems, instead of the exclusive adoption of any of them. We have, therefore, many remains of the old Galenic doctrines, many parts derived from the mathematical reasoning of the mechanicians, while considerable use is likewise made of the supposed chemical changes that occur in the fluids. His grand error was in preferring this eclectic plan to that of original observation, in endeavouring to build a theory upon the conjoined speculations of others, instead of founding it upon principles deduced from the observation of the appropriate powers of the living body.

With this illustrious character, we shall close the 4th epoch, into which we have divided the history of medicine, including a period of about three centuries, during which the attention was principally occupied in applying to medicine the knowledge and learning which were borrowed from the other departments of science, when the mind had succeeded in throwing off the fetters of authority, but had not yet discovered the best means of using its newly acquired power.

CHAP. V.

The fifth Period of Medicine. from the middle of the 18th Century to the present Day.

We have assumed the middle of the last century as the commencement of the 5th epoch, which we have pointed out in the history of medicine. It is not so clearly denoted by the occurrence of any decisive event as the former divisions, nor is it easy to assign its exact boundary; but the general state of medical science during the last 60 or 70 years has experienced a change, which fully entitles this period to be distinguished from that which preceded it. If we characterize the last as the age of learning, we may regard this as the age of observation and experiment, when scholastic disputation was totally disregarded, when abstract theory was comparatively little attended to, when the value of the inductive mode of philosophizing was universally recognized, and when hypotheses were professedly built solely upon the generalization of facts. This plan of proceeding has not indeed, in all instances, been strictly adhered to; our observations have not been always correct, nor our experiments well conducted, nor have our investigations been always pursued with sufficient caution; but a spirit of free inquiry has ultimately prevailed, and the exertions which were formerly directed to the accumulation of learning, have been, for the most part, bestowed upon the acquisition of knowledge. A necessary consequence of this state of things, is to detach the mind from the influence of theories and systems, to diminish the authority of great names, to induce individuals to rest more upon their own powers, and to be less servilely devoted to the tenets of others. In former times, the whole medical world was divided into two or three great sects; and every one conceived it absolutely essential to attach himself to some school, or to range himself under the banners of some distinguished leader; but during the period of which we are now going to treat, a great variety of speculations and doctrines were perpetually brought before the public, some of which, from their intrinsic merit, acquired a degree of popularity, while the greatest part of them quickly resigned their place to others, that seemed to be founded on more correct principles, or attracted more notice from their novelty.

These circumstances will obviously render it impossible to continue our sketch of the history of medicine in the same regular manner as in the former parts of it, but it is desirable to attempt some arrangement, both for the purpose of assisting the memory, and in order to enable us more readily to compare the merits of the different authors who have enjoyed any considerable share of reputation. Perhaps we may the most conveniently arrange the medical writers of the present period into five divisions. *First*, The metaphysical physicians, to whom the name of Animists or Spiritualists has been applied, and who may be regarded as having adopted, to a greater or less extent, the hypothesis of Stahl; according to which, the operations of the animal economy depend upon the agency of a principle superadded to the material part of the body, and affording it its vital energies. Connected with this sect, and indeed sliding into it by almost imperceptible gradations, we may rank a class of writers, who, without directly assuming the existence of any hypothetical principle, which produces all the changes of the living body, have particularly applied themselves to the examination of the phenomena of life. They have professed to ascertain the laws of the animal economy by actual observation, and by this means to discover what are the appropriate powers or qualities of the living body, and in what respect these powers or qualities differ from those of inanimate or unorganized matter. Although they have advanced in the accomplishment of their object by slow degrees, and with imperfect success, yet their method of proceeding is founded upon correct principles, and it is the only one from which we are ever to expect that a just theory can be deduced. To this class the name of Vitalists may be applied; a term which has indeed been used in a different sense, but which, we conceive, may with peculiar propriety be given to those, whose leading object is to investigate the phenomena of life. In the third class, we may place the Eclectics, including the disciples of Boerhaave; those who still retained their deference for the erudition of their predecessors, and who were more anxious to derive their doctrines from the collected opinions of others, than to deduce them from original observations. We may form a fourth class of the modern chemists, who, taking advantage of the discoveries that were made during the last century, have endeavoured to apply them to the explanation of the phenomena of pathology and therapeutics; thus adopting, in some respects, the same mode of reasoning with the followers of Sylvius and Willis, although it must be admitted, that they derived their speculations from more correct data. After these four classes, who may, in some measure, be considered as respectively belonging to so many separate sects, possessing principles, and proceeding upon a basis of reasoning more or less confined to themselves, there still remains a very considerable number of medical men, and those among the most eminent for their talents and acquirements, who are not to be brought under any of these denominations, being merely recorders of individual facts, or historians of particular diseases, who absolutely reject all hypothesis, considering the science of medicine as not sufficiently advanced to admit of any satisfactory theory, and solely applying themselves to the improvement of practice. It necessarily follows, from the nature of the arrangement which we have proposed, that it cannot be very strictly adhered to in all instances. It will not unfrequently happen, that the same individual may be included under more than one of the above classes; or that there may be other cases, in which it will not be easy to determine, in which division certain writers should be classed; but, with some limitations and exceptions, we shall probably find the above method sufficiently correct for our purpose.

Although the hypothesis of Stahl appears to us gratuitous and visionary, yet at the time of its first promulgation it met with many advocates. It was admired, both in consequence of the facility with which it seemed to explain the most intricate operations of the animal economy, and probably also from a kind of mystical obscurity which is attached to its fundamental principles, and which generally proves more attractive than the clear deductions of correct investigation. There were, indeed, few persons who adopted the doctrine in its full extent, and who conceived of the existence of a distinct principle, endued with consciousness and intelligence, as it were incidentally connected with the body, and rather directing its functions, than actually forming a part of its constitution. Yet, with some modifications, the hypothesis of the Spiritualists, or Animists, had many followers. It seems to have been the favourite doctrine among the Germans, and in this country it was embraced by some physicians of eminence. Two of its most zealous defenders, who adopted it with the fewest alterations, were Juncker and Alberti, both of whom were professors in the university of Halle. They were nearly of the same age, and flourished at the commencement of the 18th century. Their publications were numerous, and are generally supposed to contain a clearer exposition of their peculiar hypothesis, than is to be found in the works of Stahl himself. There is a considerable similarity between their characters, as well as between their pursuits. Perhaps the former is to be regarded as the more learned and judicious, and the latter the more animated and elegant writer; but their various productions are now seldom referred to, except as subjects of curiosity, or as specimens of the kind of reasoning which was employed by a sect, that for some time enjoyed so great a share of popularity.

The only professed disciple of Stahl, who was a native of England, and whose posthumous celebrity is so considerable as to entitle him to a place in this sketch, is Nicholls. He was born in the metropolis, at the termination of the 17th century, and after receiving his education at Oxford, and visiting the principal medical schools on the continent, he settled in London as a practitioner, and went through the different gradations of professional honours until he attained the rank of court physician. But what principally renders his works an object of attention at this time, is his unqualified approbation of the metaphysical hypothesis, which he maintained in his treatise, *De Anima Medica*, where he expressly contends for the existence of a superintending rational principle attached to the body, and acting spontaneously in the prevention and cure of disease.

But although the number of those who embraced the Stahlian hypothesis in its fullest extent (or at least of those who have been so far distinguished as to claim any particular notice in the history of medicine,) was not very considerable, yet a large and respectable sect originated from this source, to whom the name of semi-animists has been applied. Under various appellations these admitted the existence of the superintending principle, but they considerably restricted the powers which had been assigned to it by Stahl; they disclaimed the idea of its independent consciousness, regarding it as one of the organs or appendages of the living body, the operations of which, although directed to a different object, were exercised upon the same principles with all the other vital functions.

Among our own countrymen, one of the most noted of this class was Whytt. He was born at Edinburgh in the beginning of the 18th century; after having studied in the first schools, both in this island and on the continent, he settled as a practitioner in his native city, and finally became professor of medicine in the university of that place, then advancing to that high reputation for which it was afterwards distinguished, and to which he in no small degree contributed. His works which are the most known, are those that were written in opposition to the doctrines of Haller, with whom he engaged in a warm and rather acrimonious controversy, respecting the nature and causes of the vital motions of the body. Whytt attributes these motions to the operation of the soul or sentient principle, something distinct from the material part of our frame, yet necessarily attached to it. It differs from the *anima* of Stahl in not being possessed of an independent faculty of consciousness, and in performing its actions in consequence of the effect of external causes, and not from a species of independent volition. The hypothesis of Whytt, however, labours under the objection of appealing rather to metaphysical than to physical considerations, and in ascribing certain operations more to the influence of final causes, or to their supposed necessity for the well-being of the system, than to the action of those powers, the existence of which may be deduced from a careful examination of the phenomena of life.

To this sect also belongs Sauvages, a man who, on many accounts, deserves honourable mention in the history of medicine. He was born in the province of Languedoc, at the commencement of the 18th century, received his professional education at Montpelier, at that time in high reputation as a medical school, and afterwards became one of its professors. He is principally known to posterity as being the first who formed a regular arrangement of diseases into classes, genera, and species, similar to the method which had been pursued in the various departments of natural history, prefixing to each a short character or definition, and assigning its generic and specific name. Although the nosology of Sauvages may now be considered as superseded by later attempts of the same kind, and by the general increase of information, yet it must be regarded as an undertaking of great merit, and one which materially tended to the promotion of medical science, by producing more correctness in the use of terms, and in this way giving more accuracy to our ideas. Sauvages was a zealous defender of the doctrine of the animists, so far as regarded the agency of the intelligent principle in the prevention and cure of disease, but to this he united a certain portion of the mathematical or mechanical principles, which he applied to the explanation of many of the phenomena of pathology. To the same class we may refer the favourite pupil and successor of Boerhaave, Gaubius. He was contemporary with Sauvages, and like him adopted the doctrine of the superintending intelligent principle; but his chief claim upon our attention rests on the more stable foundation of his numerous learned works in pathology and other branches of medical science. His essay on pharmaceutical prescriptions, his remarks on nosology, and his institutions, place him among the first physicians of his age, and enabled him to support the credit of the university of

Leyden, after the loss of his illustrious preceptor. He is best known in the present day by his opinions concerning the actions and properties of the living solids, in which he proceeded in the path that had been entered upon by Baglivi; transferring to them many of the effects which had been previously attributed to the fluids; and although his doctrine is in many respects too mechanical, and shows him to have been ignorant of the principles which were afterwards developed by the vitalists, yet they contributed to the downfal of the humoral pathology, and to the establishment of the more correct hypothesis of their antagonists.

While the theory of the spiritualists, which at its first appearance attracted so much attention, continued to diminish in popularity, as its fundamental positions were more minutely examined, so the rival doctrine of the vitalists gradually increased in reputation from the same cause. We have already pointed out Hoffmann as one of the first writers who entertained a correct view of the subject, or, at least, among the first who were aware of the necessity of investigating the properties of the living body, instead of supposing the existence of an intelligent agent, whose power might be conceived competent to explain the phenomena. Glisson, an English anatomist and physiologist of considerable ability, had indeed, nearly a century before this time, attempted to ascertain the properties of the muscular fibre, and to discriminate between its powers and those of the nervous system. He even proceeded so far as to give to the former the appropriate name of irritability, a name which has since come into very general use, and is the one most commonly employed in the present day. But, notwithstanding the ingenuity displayed in his works, they were not much attended to by his contemporaries, and can scarcely be said to have produced any great effect upon public opinion. Bordeu, a French physician, who flourished in the middle of the 18th century, seems to have made some advances in the same track; but the individual to whom the merit is especially due, of actually pointing out the characteristic properties of the living body, and distinctly showing in what respect they differ from the other powers of matter, and arranging them according to their specific differences, is the celebrated Haller. The history of this eminent man belongs more to anatomy and physiology than to medicine; but the numerous and important improvements which he introduced into those branches, extended their influence over every collateral department. By his correct description of the laws of the muscular and nervous systems, he gave a new impulse to the progress of pathology, while, by the example which he held out, of avoiding all hypothetical opinions, and of deducing his principles entirely from experiment and observation, he performed a still more essential service to the medical sciences.

Among those who made the study of medicine their immediate object, and who have applied themselves only as it were incidentally to the other departments of knowledge, no one, in modern times, has acquired a higher rank in public estimation than Cullen. For a long series of years he occupied the medical chair in the university of Edinburgh, with the most distinguished reputation, so as to have had a great share in raising it to be the first school of medicine in Europe. His public situation, as well as the peculiar nature of his talents, which were particularly adapted for the office of an instructor, contributed to give an unusual degree of influence to his principles, and for some time his doctrines received almost the universal assent of his contemporaries. He was a man of a shrewd and penetrating genius, sagacious in detecting the fallacy of the old hypothesis, while he proposed his own with a degree of candour, and even with a spirit of philosophical scepticism, that tended to render them more acceptable than if they had been urged upon the mind with dogmatical positiveness. He professedly borrowed from Hoffmann some of the leading points of his theory, and by taking advantage of the improvements that were made at that period in chemistry and physiology, he produced a system of pathology which appeared to be founded in fact, and seemed to be consistent in all its relations. The additional information which has been acquired since his time has indeed discovered, that the different parts of the edifice were not erected on an equally stable foundation, and some, even of his most favourite speculations, have been either entirely discarded, or have been so far new-moulded, as to retain only a slight trace of their original. This has been remarkably the case with the hypothesis of excitement and collapse, which was certainly the parent of the stimulation and exhaustion, and the direct and indirect debility of the famous Brown.

This singular character was, as well as Cullen, a native of Scotland. He was not originally designed for the medical profession, and neither his education nor his turn of mind seem to have been of that liberal cast which were able to compensate for the deficiency. But what he wanted in information and learning, he endeavoured to supply, by a bold and ardent turn of mind, which led him to resist all obstacles, and to undervalue those acquirements which he found were beyond his reach. He was possessed of considerable genius and originality, and seizing upon a few great principles, which at first view seemed to be established by an appeal to facts, he disregarded all minute detail, and proceeded to form an hypothesis, which he announced with the utmost confidence, and which produced a prodigious effect both upon the theory and practice of medicine. It was received with avidity by all the younger part of the profession, for it held out to them the most compendious road to knowledge, by which the application of a few simple principles might accomplish more than all the accumulated learning of schools and colleges. Its fame soon spread beyond its native country; it met with zealous defenders in various parts of the continent, and especially in Germany, where it was almost universally adopted, with a degree of blind devotion. It overthrew the Boerhaavian system; nearly superseded that of Cullen; and for some time almost put an entire stop to research, by the persuasion, that truth having now been certainly discovered, farther inquiry was become unnecessary. The diligent observers of the phenomena of life perceived indeed many objections to the doctrine, even in its fundamental positions; and after the first tumult of applause had subsided, and the mind was become sufficiently cool to examine it without any undue bias, it was found to be totally inadequate to fulfil the promise which it held out. It was not, however, without its use in more completely detaching the mind from the learned hypotheses which had prevailed in the former period, and in demonstrating the effect of certain remedies, which although often ill adapted to the object of the practitioner, yet they tended to illustrate the operations of the animal economy, while they serve as land-marks to direct the path of succeeding inquirers, and point out the rocks and quicksands which it behoves them to avoid.

After an interval of some years, which was principally occupied by the controversy to which the Brunonian hypothesis had given rise, a work appeared, proceeding upon the same leading principles with the *Elementa Medicinae*, but in its spirit and execution of a completely opposite nature, the *Zoonomia* of Darwin. Darwin resembled Brown in possessing genius and originality, but the resemblance can be pursued no farther. The genius of Brown was powerful and energetic, that of Darwin was acute and refined; while it may be presumed, that the natural bent of their understandings was in either case fostered by their mode of education and acquired habits. To a knowledge of medicine in all its departments, an extensive range of practice, and a familiarity with all the physical sciences, Darwin united a fondness for minute detail and experimental research, and he has consequently given to his system more the appearance of elaborate investigation, and of the accurate finishing of all its subordinate parts, than is to be found in any medical theory which was ever offered to the public. Each individual speculation promises to be supported by direct facts, either drawn from the records of his own practice, or deduced from the authenticated experience of others, while liberal use is made of all the scientific discoveries of the age; and the conjoined operation of both physical and metaphysical learning is employed to connect and cement the various members which compose the splendid whole. Yet this great work seems to have produced little effect; and even after the short interval which has elapsed since its publication, it is little read, and seldom referred to. Its basis appears to be unfounded, and its parts incongruous; the illustrations and proofs by which it is supported, are conceived to be either inapplicable, or of doubtful authority, while it bears an aspect of over-refined and even fanciful hypothesis, which gives it the air rather of the production of a creative imagination than of a matured judgment.

We have placed Brown and Darwin among those writers, who deduced thier doctrines more from the actual examination of the properties of the living body than from pre-conceived opinions; yet, with respect to the former at least, the propriety of this arrangement may be questioned; and we must acknowledge that he is indebted for it more to the relation which he bore to Cullen and Darwin, than to any labour which he bestowed upon this kind of investigation. But as he professed to make nature his guide, and to be merely the interpreter of her phenomena, we may be allowed to retain him in his present situation, however widely he may have deviated from the correct path. With more justice we may place in the same division another celebrated individual, notwithstanding he differed very widely in many respects from his contemporaries, John Hunter. The reputation of Hunter rests principally upon his anatomical and physiological researches; but his peculiar opinions have had so considerable an influence over the doctrines of pathology, that he becomes a distinguished character in the history of medicine. His genius, which was very considerable, was of a cast dissimilar to that either of Brown or Darwin. Possessed of much more professional knowledge than the one, and of much less scientific refinement than the other, he devoted his attention to the patient investigation of facts; an exercise in which he proved eminently successful. But he was not satisfied with this occupation; he was anxious to arrange his materials into a systematic form; and partly perhaps from the deficiencies of his early education, and partly from an independent turn of mind, which led him to place more confidence in his own powers, than in the information which could be collected from others, he broached many new doctrines, and introduced a kind of novelty, both of thought and expression, which had a very extensive influence over the opinions of his contemporaries. To no one among the moderns, except Haller, are the various departments of our art more indebted for the extent and importance of his discoveries than to Hunter; but he did not possess the comprehensive mind, and the well-poized judgment of his predecessor. Hence in his theories we meet with the grossest absurdities; physical and final causes are confounded together; metaphysical expressions are substituted for the generalization of facts; and explanations of phenomena are offered, which, when analysed, consist more in a peculiar phraseology than in the developement of any important principle, or in referring the particular fact in question to any more general train of events. Many of Hunter's speculations bore a close resemblance to the doctrines of the Animists; and, indeed, the fair deduction from some of his expressions would imply his belief in an immaterial principle, connected with the body, but possessed of distinct consciousness and intelligence.

We shall close this list of distinguished characters with that of Bichat, a man who is no less deserving of our respect for the additions which he made to our knowledge, than of our admiration for the short space of time in which he accomplished them. The events of his life are few and simple. He was the son of a physician in the south of France, and, from an early period of his life, devoted his whole attention to the subjects connected with the profession. After receiving the preliminary parts of his education in a provincial town, he repaired to Paris, where he pursued his studies with the utmost ardour; and immediately after their completion, entered upon the double duty of a practitioner and a public teacher. In the mean time he continued his anatomical and physiological researches without relaxation, and published the result of them in several elaborate works, when, in the midst of his brilliant career, he died prematurely, at the age of 31.

Bichat appears to have been endowed, in an eminent degree, with those intellectual qualities which were best adapted for the department of science on which he exercised them. His industry and preseverance in the investigation of knowledge were unbounded; and he was so far successful in his researches, that the number of new facts which he discovered or illustrated, would have been alone sufficient to have established his reputation as among the first of his contemporaries. But he is perhaps still more to be admired for the philosophical spirit which he displayed in the arrangement of his materials, than for his skill in their detection; for even if we should conceive that his divisions are occasionally too minute, and partake somewhat of metaphysical subtilty, yet we must admit that his views of the animal economy were original and perspicuous; and although we cannot coincide with them in every particular, yet we consider them as directly tending to promote correct and philosophical opinions on the subject.

In the third class of modern physicans, those whom we have named the Eclectics, we shall find many individuals distinguished for their learning and accomplishments, who obtained a high degree of respect, both for their general science and for their medical knowledge. Among them are included most of the professors and teachers in the universities of the continent, and many of the voluminous writers, who published systems of medicine, until towards the conclusion of the last century. As their doctrines were, for the most part, borrowed from their predecessors, it will not be necessary to enter into any minute examination of them. Although by their learning they supported the credit of the profession, and by their habits of industry they produced many elaborate works, yet the improvements which they made were, comparatively, of little moment, and their effect upon the general state of science was not very important. Both in France and in Germany the humoral pathology maintained its ground, long after it had been generally abandoned in this country; and while Cullen was advancing his new speculations in the university of Edinburgh, and was illustrating the action of the vessels and the operation of the nervous system, the Boerhaavian doctrine, with the lentor and acrimony of the fluids, was still taught by Gaubius, Vogel, Selle, Stoll, Sagar, Burserius, and others, and was received, as the popular medical creed, in Leyden, Paris, and Vienna.

One of the most celebrated of the eclectics, whose works have been the most generally known beyond the limits of his own country, and who is justly entitled to our respect, from the ardour with which he applied to the improvement of his profession, is Van Sweiten. He was a native of Holland, and held a medical professorship in the university of Leyden, of which he was deprived in consequence of his religion not coinciding with that of the state. At the invitation of Maria Theresa he removed to Vienna, where he filled an office similar to that of which the bigotry of the Dutch had deprived him in his own country. His extensive learning, and the exellence of his character, procured for him a degree of respect and authority which extended his influence beyond his own profession, and for many years he maintained a kind of general superintendence over the interests of science throughout the Austrian dominions. He was a man of an austere temperament, and not much disposed to keep pace with the progress of modern discoveries, or to alter his sentiments upon any topic, when they had been once decided; but as far as respects profound erudition, and a complete knowledge of the previous history of medicine, few persons have ever excelled or even equalled him. His principal work is a commentary upon Boerhaave's *Aphorisms*, which are expanded from a single 12mo. to five ample 4tos, in which every doctrine and opinion of the original is enlarged upon with a degree of prolixity, which at present we are disposed to think unnecessary and tedious. But although we have now lost that veneration, which was formerly associated with the name of Boerhaave, and notwithstanding all the modern improvements which have been introduced into practice, the commentaries of Van Sweiten still retain a considerable degree of their original popularity, and must always be regarded as a very valuable collection of medical facts, well arranged, and faithfully recorded.

Did not the limits to which we are necessarily restricted, confine our observations to what is properly comprehended under the denomination of medicine, we should have to notice, in this part of our sketch, many illustrious names, who have indirectly contributed to the improvement of the science, perhaps no less than those who have more immediately devoted themselves to it. The discoveries that were made in anatomy during the 18th century, were connected with a minute investigation into the causes of disease, as indicated by visible changes in the structure of the organs; and the knowledge that was thus obtained had a most powerful influence in counteracting the false hypotheses which had hitherto prevailed, and in introducing into medical disquisitions the same species of inductive reasoning, which had been applied to the different branches of natural philosophy. The person who may be considered as having led the way in the correct application of anatomical research to the improvement of pathology, is Bonetus, and his method was assiduously pursued and extended by the celebrated Morgagni. There are few individuals to whom medicine is more indebted than to Morgagni, who spent a long life in cultivating this branch of the science; and, in addition to the other claims which Haller possesses to the gratitude of posterity, we must not omit to notice the zeal with which he prosecuted the study of morbid anatomy, and the application which he made of his knowledge to the illustration of the phenomena of disease. In the same department, although possessed of an inferior degree of merit, we may place Lieutaud, who was for some years chief physician at the court of Versailles, and who was eminent both for his skill as a practitioner, and for his accuracy as an anatomist. He is, however, more especially entitled to our regard in this place, in consequence of his great work, "*The Synopsis*," which contains the result of much correct observation, and is particularly valuable, as exhibiting a complete view of the state of medical practice in France. With respect to his general principles, Lieutaud may be classed among those whom we have styled eclectics; he retained some parts of the mathematical doctrines, while he is, to a certain extent, a humoralist, and, together with these, he united some of the opinions that were then gaining ground, respecting the operations of the vital powers in the animal economy.

The "*Institutions*," of Burserius bore the same kind of relation to the practice of Italy, that Lieutaud's synopsis does to that of France. He was also an eclectic, taking different parts from the systems of his predecessors, and combining them into a whole, which is more to be admired for the elegance of its details, and for the copious information which it contains, than for the selection of the materials. Burserius was, however, a man of candour, as well as of learning; and although many of his doctrines were founded upon the humoral pathology, in others he embraced the more modern opinions of the solidists; and, upon the whole, the works of this author present not an unfavourable view of the state of medical science in Italy.

The chemical hypotheses of Sylvius and Willis had been in a considerable degree superseded, first by the mechanicians, and afterwards more effectually by the spiritualists and the vitalists, but a certain portion of this doctrine still continued to prevail, and influenced the speculations of some men highly respectable for their general science, as well as for their professional knowledge. The original ideas respecting the fermentation of the fluids had never been entirely forgotten, and after undergoing several successive modifications, they were revived in a new form about the middle of the last century, by a sect of pathologists, principally belonging to our own country, who founded their opinions upon what appeared to be a correct deduction from observation and experiment, and who produced no less effect upon practice than upon theory. According to their doctrine, there always exists in the animal body a tendency to the putrefactive fermentation, which in a state of health is counteracted, or prevented from running into excess. But there are various morbid conditions of the system, where the fluids acquire an unusual tendency to the putrid state, when sometimes even the solids partake of the same tendency, and the whole frame becomes disposed to run into decomposition. The hypothesis of the putrid origin of diseases was advanced, in its most consistent form, by Pringle, who endeavoured to subject it to experimental proof; it was likewise supported by Huxham and M'Bride, and entered into the speculations of most of the distinguished practitioners of the age. A doctrine nearly similar, although derived from a different train of reasoning, prevailed to a considerable extent in Germany; and we still retain in our medical language many of the phrases which took their origin from this source.

A new kind of chemical pathology was started, at the conclusion of the last century, founded upon the discovery of the different gases, which was adopted by many individuals, both in this country and in Germany. For some time it promised to throw a considerable light upon the actions of the animal economy in general, and particularly upon the operation of remedies; but although the facts upon which it was built were many of them correct, the inferences that were drawn from them have been found to be fallacious. We particularly allude to the employment of the factitious airs in diseases of the lungs, and to the supposed action of acids in the cure of scurvy, to the attempts which were made to oxygenate and deoxygenate the blood, and to other similar practices, some of which have proved entirely abortive, and others, although to a certain extent useful, have been more satisfactorily explained upon different principles. Of these, however, we shall take more notice, when we come to remark upon the treatment of particular diseases.

In such a brief sketch of the history of medicine as we are now attempting to lay before our readers, we must necessarily pass over, in a very cursory manner, the writers who belong to our fifth division; those who either altogether disclaimed theory, or who have professed to be merely collectors of facts, devoting themselves solely to the investigation of particular diseases, or even of single cases. Although individually of less weight and authority than the systematic writers who have passed under our review, yet they have produced, by their conjoined labours, a body of information, which has contributed, in an equal, or perhaps in a greater degree, to the improvement of medicine. At the head of this class we must place Heberden, whose talent at nice discrimination has stamped an inestimable value upon his volume. Among his contemporaries or associates we may particularise Fothergill, Withering, and Percival, whose essays upon insulated topics make us regret that they have not left behind them more numerous memorials of their practical skill; Russel, Cleghorn, and Lind, who so correctly described the effect produced upon the body by a residence in hot climates; Rush, whose ardent and ingenuous disposition sometimes betrayed him into inaccuracies, for which he has amply atoned by his candour in their acknowledgment; Currie, who infused into medical disquisitions an unusual degree of literary elegance; Fowler, who, by a happy temerity, converted the most deadly poisons into highly valuable medicines; and Willan, whose premature death cut short his exertions in a department of the art which he had raised almost to the rank of a new science. We refrain from adding the names of any living authors to this list, but we have no reason to apprehend that an examination of their works will lead us to consider them as in any respect inferior to those of their predecessors.[*]

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[*] We do not recollect any where to have met with so correct and candid a narration of the progress of medical science, as is furnished in the above article. It is not among the least of the merits of this lucid historical sketch, that the measure of approbation is freely meted out to the eminent men of different and rival nations. It has been too much the practice of modern writers to treat with contempt, or to pass by with neglect, the services rendered science by the Arabians. (See Cullen and others.) In the present instance the able author has not considered the Arabian physicians as the mere temporary repositories of knowledge, but has done that justice to their various merits which has been so constantly and so pertinaciously withheld.

The writer seems to have considered our countryman, Dr. Rush, as of the class of modern eclectics; we think, improperly. No author of late times has probably laboured more perseveringly than Dr. Rush, in favour of a particular system, and throughout his numerous medical writings traces of his peculiar theory are always apparent. His system may properly be considered as a modification of the doctrines of Dr. Brown, but ushered into the world under circumstances more favourable to its successful reception. In the advantages of preliminary learning and general science, in experimental research, and practical acumen, Brown can stand in no competition with Rush; while the greater elaboration of his doctrines by the latter, early begun, and continued to an advanced age; his extraordinary eloquence as a public teacher, in the then only frequented university of the American republic; and the popularity of his written productions, secured to him an ascendancy and duration which the principles of Brown, popular as they once were, never attained. The influence of Dr. Rush's opinions, and the practice deduced from them, are not confined to his native country; some of his leading principles are now making a rapid progress in Great Britain.[*] It is but justice to add, that Dr Rush seldom permitted mere theoretical views to mislead his practice; and his contemporaries will bear witness, that his prescriptions were as prudent and judicious as his speculations were ardent and adventurous. At the present day, when the pretensions of several medical universities in the country present nearly equal claims, the medical practice of the United States is by far too various to exhibit the livery of any particular sect. More recently the doctrines of sympathy, as they are termed, have been ably illustrated and defended in the Philadelphia school by Dr. Chapman, the professor of the practice of medicine; while the principles of the humoral pathology, as modified by the late researches in physiology, and the results afforded by animal chemistry, have found an advocate in the professor of the practice of physic in the New York university. (See Dyckman's Pathology of the Human Fluids, 8vo. New York, 1814.) These two theories may be deemed those most current among American physicians. It may also be stated, that however variant may be the theoretical opinions of the different American professors in the numerous institutions of the United States, they all unite in enforcing a more prompt and rigorous mode of treatment than is inculcated abroad. The immense extent of our country, and the variety of

[*] See Stock's Life of Beddoes; also Bedingfield's Compendium of Medical Practice.

Part II. PATHOLOGY.

Pathology is that branch of medicine which consists in the knowledge of the general doctrines of disease. When considered in its most extensive relations, it may be divided into Œtiology, or the knowledge of the causes of disease; Symptomatology, or the symptoms of disease, by which, from some particular appearances, we become acquainted with the nature of the morbid affection, and are enabled to distinguish it from others to which it bears a general resemblance; and Semeiology, or a knowledge of the signs of disease, by which we acquire the power of prognosticating the future changes that are likely to occur in the state of the patient. In treating upon this subject, we shall begin by laying down the general principles which are to direct us in our investigations, and shall afterwards give an account of some of the most celebrated hypotheses that have prevailed at different times.

CHAP. I.

General principles of Pathology

To obtain a complete acquaintance with pathology, or at least with that part of it which treats of the causes of disease, it would be necessary that we should understand the nature and action of the functions of the body, in their healthy state; this, however, constitutes the science of **Physiology**, and will form the subject of a distinct article. We shall therefore be obliged, in some degree, to anticipate what more properly belongs to that department; but, to avoid this as much as possible, we shall chiefly confine ourselves to an account of the immediate or direct causes of disease, and the more obvious effects which they produce upon the system. For some time after the revival of letters, while it was the custom to consider all questions of science rather with a view to certain abstract principles, than with a reference to actual facts and observations, the causes of disease were divided into various species, corresponding with the notions of arrangement deduced from the scholastic methods of the middle ages. As a specimen of this kind of classification, we may adduce the example of Charleton, a writer of considerable learning and ingenuity, who flourished in the middle of the 17th century, and who, although he adopted the Galenic principles of the humoral pathology, was distinguished for the readiness with which he embraced all the recent discoveries in anatomy and physiology. He first divided the efficient causes of disease into congenital and adventitious; the former are subdivided into natural and non-natural, the latter into external and internal; the internal are supposed to be either necessary or contingent, these again being arranged into what he styles procatarctic, a term nearly synonymous with occasional, and, lastly, into antecedent and continent. For a more correct, and less complicated arrangement, we are indebted to Boerhaave, who proposed the plan which is still generally adhered to. He divides the causes of disease, first, as they depend upon a change in the body itself, or upon the action of some extrinsic circumstances, into internal or external; afterwards, with respect to the manner in which the disease is generated, into the remote or predisposing, the occasional or exciting, and the proximate cause; the first producing that particular condition of the body, which renders it liable to be affected by the second or exciting cause, the more direct or immediate origin of the morbid affection, while the

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climate which it embraces, present diseases of a type and character which put at defiance the inert prescriptions of European physicians.

It may be excusable here to make a quotation from a memoir of Dr. Rush, inserted in the American Medical and Philosophical Register, vol. iv.

"It were no easy task to do adequate justice to the great talents, the useful labours, and the exemplary character of Dr. Rush. From a sketch of his life some idea may be formed of his incessant devotedness to the improvement of that profession of which he was so bright an ornament. His merits as a practitioner are too well known to need particular notice; he was fully aware of the great responsibility attached to the medical character, and uniformly evinced the deepest solicitude for the recovery of his patient. His kindness and liberality in imparting aid to those from whom no remuneration was ever to be expected, were unbounded, and arose from the generous impulse of his nature, and the cordial concern he felt in whatever affected the interests of his fellow creatures. His mind was of a superior order. To a perception naturally ready and acute, he united a discriminating judgment, a retentive memory, which was greatly improved by habits of close attention, a brilliant imagination, and a highly cultivated taste. He possessed a comprehensive understanding. His knowledge was varied and profound, and he eminently excelled in several departments of his profession. In his assiduity and perseverance in the acquisition of knowledge, he had no superior, and few equals. Accustomed to constant and regular exercise, his intellectual powers acquired additional vigour from employment. Notwithstanding the great fatigue he had to undergo in the discharge of the practical duties of a laborious profession, and the constant interruptions to which he was exposed when engaged in his pursuits as an author, he never for a moment abated of his ardour in the cause of science. His habits of punctuality to every kind of business in which he was employed, added to a judicious arrangement of time for his multifarious occupations, secured to him sufficient leisure for the publication of those works which have given such celebrity to his name.

"His writings claim our attention, both on account of their extent and their variety. Instead of being a mere collater of the opinions of others, he was constantly making discoveries and improvements of his own, and, from the results of his individual experience and observation, added more facts to the science of medicine than all who had preceded him in his native country. His description of diseases, for minuteness and accuracy of detail, cannot be exceeded, and may safely be regarded as models of their kind. His volume on the diseases of the mind, as far as it exhibits the infinitely varied forms which those diseases exhibit, is a storehouse of instruction. Had his labours been limited to these subjects alone, his character would deservedly have been cherished by future ages. His reputation, however, will permanently depend upon his several histories of the epidemics of the United States, which have rendered his name familiar wherever medical science is cultivated, and will hereafter cause to be inscribed upon the same imperishable column that bears testimony to the merits of Sydenham and Boerhaave, the illustrious name of Benjamin Rush. The respect and consideration which his publications procured for him among his contemporaries were such, that the highest honours were accumulated upon him in different parts of Europe, as well as in his own country; and he was admitted a member of many of the most distinguished literary and philosophical associations."

Hosack and Francis.

last or proximate cause indicates the actual change in which the disease consists.

This arrangement has been almost uniformly adopted, and, as a technical appropriation of terms, seems to be unobjectionable. The distinction between the two first, the internal and external, is sufficiently plain: nor is that between the predisposing and exciting causes less intelligible, being derived from the well ascertained fact, that, for the production of disease, it is not only necessary that a sufficient cause be applied, but that the body be in such a state as to be capable of receiving the impression of the cause. The typhus fever of this country is propagated by contagion, which is therefore to be regarded as its exciting cause; but when the same contagion is applied to a number of individuals, we find that some of them only will feel its influence, and that this liability to receive the disease may be frequently traced to the operation of some previous circumstance, which renders the body more susceptible of the action of contagion, and which is consequently styled the predisposing cause. There are certain diseases, such, for example, as the small-pox, which never occur more than once to the same person; in this case the contagion must be applied to the body constituting the exciting cause, but it is likewise necessary that the patient has never previously experienced it, and thus possess a predisposition to it, which, in consequence of some imperceptible change that is wrought upon the system by the morbid action, is afterwards lost. The propriety of the application of the term proximate cause is more doubtful, whether considered in a logical or a physical sense. It is defined to be that, which, when it is present, produces the disease; when it is removed, removes the disease; or when it is changed, changes it. A definition which can scarcely apply to any thing except the actual disease itself, and cannot correctly be considered as its cause. But as a technical expression it may not be without its use, and it is so well understood, as not to lead to any misconception; it may still therefore be retained, although the farther consideration of it does not belong to this part of our subject.

Before we enter upon the detail of the particular causes of disease, it may be desirable to make a few observations upon the nature of diseased action in general, and upon those circumstances which distinguish the morbid from the healthy state of the body. Various definitions of disease have been offered, all agreeing in their main object, but differing considerably in the expression, according as they are more or less comprehensive, or as they include more or less of the peculiar hypothesis of their authors. Perhaps the most unexceptionable definition of disease is a state of the system, in which one or more of its functions are performed in an imperfect manner. By functions we mean to express those trains of actions, belonging to the living animal, which conspire to the production of certain effects, that are either necessary for its subsistence, or for the due performance of its relations to surrounding objects. Various classifications of the functions have been proposed, of which one of the most common is that into animal, vital, and natural, founded upon the idea of their supposed ultimate object. They have also been divided into internal and external, according as they relate to the internal operations of the system, or its action upon external objects; into the functions of irritability and of sensibility, depending upon their supposed origin in the one or other of these powers or principles; and more lately a new classification has been proposed by Bichat, into animal and organic, the former denoting those operations which are peculiar to the living body, and connect it with the external world, the latter, those that refer to its own economy, and maintain the physical condition of the body. This last arrangement, which professes to be founded upon the actual relations of the system, is perhaps the most strictly scientific; but the division of the functions into animal, vital, and natural, being the one which is commonly adopted by pathologists, it will be proper to explain the meaning of the terms. We may also remark, that this division possesses some practical advantages, and, by a little accommodation, may be rendered not inconsistent with that of Bichat.

The animal functions are those which are peculiar to animal life, the object of which is to connect man with the external world, and which essentially consist in sensation and voluntary motion. They are distinguished by the limited nature of their action, both as to the length of time, and the degree of effect; for we find that after a violent exertion, either of the mind or of the body, the powers of both become exhausted, and a certain interval must elapse before they can resume their operations. It is observed that the organs by which the animal functions are exercised are double, each of them having a corresponding organ situated on the opposite side of the body. This is obviously the case with respect to the external senses, and the muscles of voluntary motion, and even the brain itself, although a single organ considered as a whole, consists of individual parts, of a specific form and structure, each of which have their corresponding part in the two hemispheres. As these functions are appropriate to the living animal, and especially distinguish it from all other bodies, so they may be regarded as the most necessary for its perfection, and as what constitute by their action the ultimate object of its existence.

The next class of functions, the vital, may be defined, those which are directly essential to the continuance of life, and which serve to maintain the organs of the animal functions in a condition fitted for the performance of their actions. The most important of the vital functions are, the circulation and the respiration. By the first the blood is carried from the heart to all parts of the body, for the purpose of preserving them in their healthy state, and enabling them to exert their appropriate powers; while, by the second, the blood, after having performed this office, and thus undergoing a certain change, which renders it no longer fit for the purpose, is acted upon by the air in the lungs, and by this means regains its vital properties. The operation of these functions is, for the most part, involuntary; they proceed with perfect regularity, and without intermission, not being liable to the same kind of exhaustion with the animal functions. These two classes of functions differ as to the degree in which they depend upon each other; the vital are capable of acting without the concurrence of the animal, while the latter are entirely dependent upon the former; hence we find that the most perfect animals alone have a nervous system, while in all cases there is either a heart and lungs, or organs which are equivalent to them in their effects. So far as we are able to detect the successive developement of the different parts of the embryo, it appears that the heart is the organ which is first formed and called into action; and that this takes place for some time before any trace of a brain can be detected.

The third class of functions, those which have been called natural, are less immediately essential to existence than the vital, and may even be suspended for an indefinite length of time without the destruction of life. Their object is to afford the system a supply of matter necessary to repair the waste which is always going forwards in its different parts. The most important of them are digestion, or the process by which food is converted into aliment; absorption, by which the products of digestion are carried into their proper situation; sanguification, by which they are changed into blood; and secretion, by which certain substances are formed from the blood, to answer specific purposes in the animal economy. The natural functions are, therefore, only indirectly necessary for existence, so far as they afford the proper materials for the other actions of the system; they are also less characteristic of animal nature, and we even find that something analogous to them occurs in vegetables. The vital and natural functions agree, in both of them referring to the internal operations of the body, while the animal functions serve to establish the relation between the body and the external world. Although it may appear that there is some ground for the distinction which has been made between the vital and the natural functions, yet they resemble each other in so many points, while, at the same time, they differ so essentially from the animal functions, that we shall find it convenient, on many occasions, to consider the whole as divided into two classes only. The term organic, however, which has been employed by Bichat, seems to us by no means correct, or to be even objectionable, as implying that the animal functions are not exercised by means of appropriate organs; on this account we shall extend the appellation of vital to the natural functions also, and shall arrange all of them under the two divisions of animal and vital.

Besides the circumstances that have been already alluded to, there are other points, in which the operation of the two classes of functions differs essentially from each other. It has been observed above, that the organs of the animal functions are double, and we generally find that the joint co-operation of both the corresponding parts is necessary for the production of the proper effect. Thus, if one side of the brain have its structure injured, the actions which depend upon the nervous system are imperfectly performed; and this is the case, to a certain extent, if one of the organs of the external senses be either destroyed or impaired. With respect to the vital functions, their organs in some cases are only single, as the heart and the stomach; and where they are double, as the two sides of the lungs and the kidneys, the complete effect may be produced by one of them alone, provided it be sufficiently capacious for the quantity of effect required. The two classes of functions differ very materially as to the power which habit exercises over them; while the animal functions require for their full developement a long course of habitual experience, and are only brought into action by the slow process of education, the vital functions commence their operations from the earliest period of existence, and, so far as the physical condition of the organ permits, are as perfect in the infant as in the adult. The power of volition over the two kinds of functions constitutes a very important point of distinction between them; the animal functions are the great theatre on which its effects are manifested, while the will has only a slight and indirect influence over the vital functions. The mental faculties, as well as speech and locomotion, while in their perfect and healthy state, are always, to a certain extent, under our control, whereas, with respect to the circulation, the digestion, and the action of the absorbents, it is completely beyond our power to accelerate or retard them. An important difference has been pointed out between the two classes of functions, with respect to the origin of their power; while the one are conceived to derive their action immediately from the nervous system, the other, it is supposed, may act independently of the brain and nerves. We are certain that in all the intellectual operations, and in every case where volition is concerned, the nervous power must intervene, and many forcible arguments have been adduced, to prove that it is not necessary for the production of the vital functions; this last point, however, is one which has been much controverted, and which must still be regarded as requiring additional proof, before it can be laid down as a fundamental position.

These remarks on the difference between the animal and vital functions, which are principally taken from Bichat, are sufficient to show that his division is founded in the natural condition of the system, while in its healthy state; but in considering the phenomena of *diseased* action, we shall find it more convenient to have recourse to a threefold division, partly coinciding with the old one, to which we have already referred. When we regard the living body in its most extensive relations, we perceive that its powers and faculties may be all referred to three principal systems or modes of action, each of which serves distinct purposes, either connecting it with the external world, or preserving the integrity of its internal organization. These are the nervous, the sanguiferous, and the nutritive; the first consisting essentially in sensation, the second in motion, and the last in certain changes in the physical or chemical constitution of its component parts. Upon a derangement in the operations of one or other of these three systems, the primary cause of all diseases may be supposed to depend, although, from their intimate connexion, and from the manner in which they act upon and modify each other, it may, in some instances, be difficult to ascertain which was the original source of the evil. We are, however, able, in the greatest number of cases, to determine this point with sufficient probability; and accordingly, when we come to treat of the classification of diseases, we shall find that, so far as we proceed upon the physical structure of the body, this will afford us the most natural foundation for our arrangement.

The exercise of the functions depends upon, and is influenced by, two circumstances, into which it will be necessary for us to inquire, before we can form a complete system of pathology; the powers which the animal body possesses, and the parts of which it is composed. The powers of the living animal body are of two kinds; those which are appropriate and peculiar to it, and those which it enjoys in common with other natural objects. The complete explanation and the full developement of these points is the peculiar province of PHYSIOLOGY, and will be discussed at length under that article. At present, therefore, we must assume, what we shall afterwards attempt to prove, that the vital powers are two, sensibility and contractibility. These qualities are distinct, both in their nature, their effects, and their seat;

the first of them constituting the intellectual operations, and the phenomena of sensation, residing solely in the brain and nerves; the second being the prime cause of motion, and being attached exclusively to the muscular fibre. Besides these, the animal body, in its various parts, exhibits many of the powers which belong to inanimate matter, such as gravity and chemical affinity, although they are frequently so modified and altered by their different combinations, as not always at first view to be easily recognized. It is indeed an important part of the business of the physiologist to assign each of them to its proper source; and to the difficulty of this investigation are we to impute many of the false hypotheses which have been formed, both with respect to the powers of the body, and their action upon each other.

The component parts of the animal body are very numerous, and may be arranged in various ways, according to the end proposed by our classification. The most obvious and ancient division is into solids and fluids, and while diseases were supposed to be derived solely from some morbid condition of these latter substances, they were naturally made almost the exclusive objects of attention. The fluids were consequently divided into several different kinds, but as the divisions were derived more from theoretical principles than from any correct notions of natural philosophy, they are now entirely discarded. The most scientific methods of arrangement are those founded, either upon the chemical properties of the fluids, or the purposes which they serve in the animal economy, and the same may be employed with respect to the solids; but it will be likewise found necessary to introduce another principle of classification, which is not applicable to the fluids, their mechanical structure. The solids have also been considered under a different aspect, the nature of their organization, and what in some measure depends upon this, their vitality, or the degree in which they possess the powers that are considered essential to life, sensibility and contractility. When we consider the subject with an immediate reference to pathology, this last circumstance will be found one of the most essential, and which bears the most correct relation to the exercise of the functions. It may, however, be questioned, whether the division of the component parts of the body into solids and fluids, although the most obvious, is in fact of much importance, and upon the whole, we are disposed entirely to disregard it, and to arrange the parts of the body solely according to the connexion which they respectively bear to its functions, modified by the more or less complicated nature of their structure.

Upon this principle, we shall form them into three classes; first, the parts which compose the organs of muscular motion and of the circulation of the blood; secondly, those which enter into the composition of the nervous system; and, in the third place, all the parts which are subservient to nutrition, and the operations connected with it, or which ultimately conduce to the same general result.

The first class of parts, the organs of motion, consist of the muscles of all descriptions, as well those which serve for voluntary motion, as those which produce the internal vital actions of the system; the muscular expansions, where contraction is produced by fibres spread over the surface of a membrane, but not connected together, so as to form what we style a muscle; and the muscular fibres, which are attached to the vessels or tubes of various kinds, and enable them to propel their contents in a progressive direction. These are the essential parts of the organs of motion, but in order to produce their mechanical action, they are provided with a suitable arrangement of membranous bodies of different kinds, either in the form of thin and flat expansions, as the sheaths and fasciæ, or in a more condensed form, composing tendons and ligaments. The muscles of all kinds are most plentifully supplied with blood-vessels, and, as far as we are capable of judging by ocular inspection, they appear to be the ultimate destination of the greater part of the minute branches of the arteries. Although differing completely in their chemical composition and in their mechanical structure, we must place the bones among the organs of motion, when we form an arrangement of parts according to their functions, these being the bases to which the muscles are attached, and the fixed points on which they react when they perform their contractions. The second class, those which compose the nervous system, may be divided, according to their uses and their structure, into the brain properly so called, the cerebellum or lesser brain, the spinal cord, the nerves, and the ganglia. With respect to their composition, these organs consist of medullary matter, some parts of which possess a mere pulpy consistence, while others exhibit more or less of a fibrous texture, surrounded and kept in their due form and position by membranes of various kinds, furnished with the requisite supply of blood-vessels, and probably also with absorbents and secretory glands.

The third order of parts, those which are subservient to nutrition, is more diversified in its organs, and exhibits a greater variation of structures, many of which have little connexion with each other, except what depends upon their all conspiring to the same object. They may be referred to the several heads of glands, vessels, and tubes. Glands are bodies of an irregular form, principally composed of cellular texture, through which vessels of different kinds ramify in all directions, producing an intricate reticulated structure; the minute connexions of which have not yet been detected. The vessels of the nutritive system, in their general structure and mode of action, are not very different from those of the circulation; they are principally distinguished by the nature of their contents and the course which they pursue. What we have denominated tubes may be regarded as of an intermediate nature between vessels and glands, or rather uniting the operations of both; like vessels, they serve to propel their contents in a progressive direction, and they resemble glands in acting upon the substances which pass through them, and in changing their chemical nature and physical properties, without the intervention of any external agents.

The relation which the different powers of the body bear to its component parts must next be considered. These powers we have already stated to be contractility and sensibility, which exclusively belong to the living body, together with many of the physical properties which are attached to various species of inanimate matter. The muscular system is the exclusive seat of contractility; some of the muscles are under the influence of sensibility, as derived from the brain and nerves, but it does not appear that sensibility is necessarily connected with their contraction, nor is the concurrence of any other physical powers essential, except, as in the case of the nerves, to maintain their proper form and structure. Sensibility is peculiar to the brain and nerves, and is found in no other part, while they are devoid of contractility, nor does their action depend upon any other physical properties, except as far as is necessary for their structure and organization. With respect to the nutritive system, its actions are more various and less appropriate. An alteration in the chemical and mechanical condition of some of the components of the body is the most important result of its operation; sensation is frequently exhibited, and motion of the minute parts is required, in order to bring the substance to be acted upon within the influence of the agents; yet both contractility and sensibility seem to be rather indirectly, than directly, concerned in the effect.

From this brief sketch of the composition of the body and its powers, we shall be able to form a conception of the manner in which the causes of disease act upon it, and of the modifications which those causes may experience, from the various circumstances by which we may suppose them to be affected. The sensibility of the nervous system, for example, we may conceive to exist in a state either of morbid excess or defect, that it may be unequally distributed to its different parts, and its actions may be perverted by a change in the physical structure of the organs. The same series of affections may be attributed to the muscular system, while, in addition to this circumstance, we may suppose that any disease of the nerves will react upon the muscles, and disarrange their functions, although otherwise in a sound state. The variety of affections to which the nutritive system is liable is so much the more numerous, as its actions are more complicated. They are not only subject to be influenced by all the morbid changes of each of its own functions, but by any alteration in the condition of the muscular power, and not unfrequently by that of the brain and nerves. All these systems act upon each other, and are so connected together, that we seldom find any of them to be much injured, or perverted from its natural train of operations, without the others sympathizing in the effect. As we advance in our inquiry, we shall examine more minutely into the nature and extent of these relations; at present we may remark, that the muscular system appears to have a more immediate connection with the nervous and nutritive systems, than either of these have with the two others. Hence, in a nosological arrangement, it will probably be found the most convenient, to commence with the diseases which are primarily to be referred to some affection of the power of contractility, and to proceed in the second place, to those diseases that belong more particularly to the nervous system.

We have divided the causes of disease into internal and external; the first signifying those circumstances in the structure of the system itself, with respect to its powers, or the action of its components upon each other, which produce a derangement in any of its functions; the latter indicating those causes, the operation of which depends upon the obvious interference of an external agent, without any previous change in the body itself. In examining the causes of disease, it is often of great practical importance to ascertain to which of these species they are to be referred, for, wherever the cause is external, the removal of it, if it be still applied, and under our control, must be the first step in the cure. As a point of theory, however, it has been doubted, whether, strictly speaking, every disease may not be ultimately referred to some external cause. If the system be in a state of health, it has been asked, whether a morbid condition of the functions can be produced, without the interference of some external circumstance, which may be regarded as the cause of this condition. The fact would seem to be, that in many cases, the internal causes of disease may be referred to some cause still more remote, which is the immediate effect of an external agent, yet we apprehend there are also, not unfrequently, instances of certain morbid changes being effected in the system, merely from the operation of original constitution or temperament, or by a long course of habit or association, where no adequate external cause can be assigned. Disease is, however, generally produced by the co-operation of both. A certain peculiarity in the constitution predisposes to certain actions, while the action is the immediate consequence of an accidental circumstance, operating as the exciting cause. Although, therefore, the division of causes into external and internal may be retained, and referred to with advantage, yet the more important arrangement of them is into predisposing and exciting. In practice it is often important to separate them from each other, and to ascertain how far the operation of each extends, and influences the result, but this cannot be effected in a general view of pathology, because the same circumstance becomes at one time the predisposing, and at another time the exciting cause of a morbid affection. It must, however, be observed, that there are certain things which generally act as the predisposing causes of disease, and others as the exciting causes, and although there are, perhaps, no predisposing which may not occasionally be converted into the exciting causes, yet there are many exciting causes which never act by merely predisposing to disease. Cold acts as a predisposing cause, when it renders the body more liable to receive the contagion of typhus, but cold is itself the exciting cause of catarrh and rheumatism. The contagion of typhus is not, however, the predisposing cause of any disease; if it do not produce its own specific effect, it is totally inert.

Hitherto we have considered the causes of disease principally with respect to their effect upon the body, but we must now regard them with a reference to their own nature and mode of action. One of the first regular arrangements that was made of the morbid causes of disease, was into the non-naturals, as they were called, a fanciful and inapplicable term, intended to express those circumstances, which, although affecting the body, are not strictly belonging to its nature. They are included under the six heads of air, aliment, exercise and rest, mental emotions, repletion and evacuation, sleep and watchfulness. Boerhaave proposed a division of the exciting causes into four classes, under the following titles, ingesta, comprehending air, food, drink, medicines, and poisons; gesta, under which are included motion, either of the whole body, or of any of its parts, affections of the mind, sleep and watchfulness; retained or excreted substances, whether salutary or morbid; and, lastly, external applications of all kinds, such as air, vapours, fomentations, baths, clothes, ointments, plasters, and bodies which produce wounds, contusions, or erosion. We conceive that these arrangements are objectionable, both as omitting some circumstances which have an important influence on the generation of disease, and as not sufficiently distinguishing between the circumstances which are properly extrinsic, and those which arise out of the necessary actions of the system. Boerhaave's division seems still less correct than the common one, because, while it is liable to the same objection, it is, in a great measure, artificial, bringing together under the same head those causes which have little or no natural connexion with each other.

Perhaps the most natural basis of an arrangement of the causes of disease is, first, into constitutional and extrinsic, an arrangement which will at the same time nearly coincide with that into predisposing and exciting; and, in the second place, we may regard them according to their mode of operation, whether they act upon the powers peculiar to animal life, or whether they affect the body as a physical agent. Under the first class of constitutional causes, we may rank hereditary disposition, original temperament, the peculiarities which attend upon age and sex, certain permanent states of the constitution produced by education, modes of life, or even accidental occurrences, states of the system induced by different trades and occupations, mental emotions, irregularities with respect to sleep, consisting either in its excess or defect, the excess or defect of exercise, and the state of the various secretions, whether excessive or defective, or altered in their physical or chemical properties. Under the head of extrinsic causes we may place specific contagions, noxious vapours, poisons, irregularities or extremes of temperature, impure air, unhealthy climates, improper diet, and, lastly, accidents, strictly so called. All these circumstances which act upon the body, must to a certain extent affect its vital properties; and it is obvious that this will be more particularly the case with respect to those of the first class, which we have denominated constitutional, while the operation of many of the second set of causes consist in the combined effect of their actions upon both its vital and its physical powers. The full developement of this subject will necessarily come under our consideration in a subsequent part of this article, when we give an account of particular diseases; at present we shall only offer a few observations, which will be necessary to illustrate the general principles of pathology.

The peculiarities which distinguish individuals are no less conspicuous in their constitutions than in their countenances, and in the same manner we can no less doubt that these internal peculiarities are transmitted from parents to their offspring, than the more obvious ones connected with the external form. The question has often been discussed, how far any disease can be regarded as hereditary? But the discussion is rather metaphysical than medical; the greatest number of those affections which are usually styled hereditary, do not make their appearance until some years after birth. It has been asked, whether in this case we are to conclude that the morbid action exists during this interval, and has remained in a dormant state? It is sufficient to reply to this question, that it is not essential to the doctrine of hereditary diseases to suppose the existence of this latent condition, it is only necessary to conceive of a state of the body, which renders it liable to have the morbid affection generated by causes, which would not produce any effect upon a constitution that was not possessed of this peculiarity. It is supposed that scrofula may be produced by the combined operation of poor diet, a cold and moist atmosphere, together with other circumstances which generally tend to weaken the powers of the body; but if precisely the same causes be applied to two individuals, one born of diseased, and the other of healthy parents it is well known that the former will almost certainly be affected by the disease, while the other will probably escape. Besides these obvious peculiarities derived from parents to their offspring, which lay the foundation of or produce the tendency to disease, there are others, no less obvious, which cannot properly be considered as morbid, where the conformation of the body and its powers exhibit a specific character, which displays itself as well in the internal operations of the system, as in the effect of external agents upon it. The description of these characteristic differences, or temperaments, as they have been styled, belongs more to physiology than to pathology, because they are not immediately connected with disease, and indeed, to a certain extent, attached to all individuals, the most robust as well as the most delicate. We have, however, very frequent occasion to recur to them, and to bear in mind their general effect upon the constitution, as well as upon particular diseases; for although they are not in every instance equally well marked, and there may even be many persons to whom it would be difficult to assign any definite character of this kind, yet there are comparatively few in whom either the symptoms of disease, or the effect of remedies, is not influenced by some characteristic peculiarity, either in the powers of the body, or the manner in which the various functions are exercised.

The doctrine of temperaments was much insisted upon by Hippocrates, and, since his time, many attempts have been made to point out those circumstances which afford the most striking characteristic differences in the human constitution, upon which an arrangement of temperaments might be established. Each author naturally proceeded upon the principles of his own hypothesis, and as it has unfortunately happened that they have been either incorrect or not sufficiently comprehensive, so from the original division, derived from the four supposed elements of the blood, down to that of Darwin, deduced from the modes of action of the vital power, none has been proposed, against which fundamental objections might not be urged. In this instance, however, as in many others, we shall be induced to conclude, that the great father of medicine, although deficient in his hypothesis, was accurate in his observations; for, after all that has been written upon the subject, there is perhaps no classification of temperaments better founded than the one which he has pointed out. The names which he applied to them, of sanguine, phlegmatic, choleric, and melancholic, can only be admitted either as being sanctioned by the authority of long custom, or because we might feel it difficult to substitute in their room any which should be free from objections. Independently, however, of the denomination applied to them, or of the causes which gave rise to this peculiar nomenclature, we conceive that the above division will be found to be the most natural one, and that all those cases, where any strong discriminative features can be perceived, may be referred to one of the above species, or to some combination of them. As we have already remarked, the full explanation of the subject of temperaments belongs to the physiologist; so that we shall attempt no more, in this place, than to give a general account of those circumstances which may be considered as constituting their leading characters.

The sanguine temperament, as its name imports, is distinguished by the large proportion of blood existing in the vessels, denoted by their size, and the strength of their pulsation. At the same time, the physical composition of the body seems to indicate a peculiar delicacy in its texture; the skin is thin and smooth, and is plentifully supplied both with arteries and veins, the former giving it its beautiful bloom, the latter indicated by the blue lines which are seen passing in all directions beneath its surface. The hair is of a light brown, sometimes red or flaxen; the eyes generally partake of the colour of the hair, while the organ is large and prominent, the pupil being expanded, and possessed of little mobility. The circulation is quick, and easily accelerated; the arterial system is full, and the secretions of all kinds are copious; the nerves are easily excited, and the mental impressions of all kinds are considerable, in relation to the cause producing them. The powers are easily called into action, but their energy is soon exhausted, and the individuals are more remarkable for quickness than for their capability of long continued exertion.

The phlegmatic temperament agrees with the sanguine, in the relaxed state of the solids, and in the softness of their texture; but it essentially differs from it in the small proportion of blood which is in the vessels, producing paleness in the countenance, together with a weak and small pulse. The skin is smooth, but without the vascular appearance which gives so much beauty to the sanguine constitution, while the body is apt to be overloaded with fat, so that both the elegance of its form, and its capability of exertion, are encumbered by its unwieldy bulk. The languor which characterizes the circulation is no less conspicuous in the operations of the nervous system, which is not easily roused, and the efforts, when they are made, are feeble and without energy.

The next temperament, the choleric, is completely different from the two former, although perhaps it is less frequently to be met with in its most perfect or unmixed state. We may observe, in some degree, the same quickness of the circulation which we find in the sanguine constitution; but the vessels seem to be more dense, and less distended. The texture of the body is often delicate, and its parts small, but they are compact and firm; the complexion is of a clear olive tint, enlivened with a sufficient portion of colour; the eyes are generally dark and brilliant; the actions, both animal and vital, are energetic and steady, less rapid than those of the sanguine temperament, but capable of a longer continuance of exertion. The mind partakes of the character of the body; it possesses quickness and vivacity, united to perseverance; and, upon the whole, there is no state, either of the corporeal or the mental powers, which may be regarded as approaching more to the perfect condition of human nature.

The melancholic temperament is, in all respects, the most opposite to the sanguine; the physical constitution of the body is strong, its parts firm and dense, the skin thick, the hair and eyes black, and the complexion dark. The blood vessels are large, but the current moves slowly through them; the secretions are scanty, and their quantity is not easily increased; the irritability of the fibre is excited with difficulty, but the muscles are powerful, and capable of long-continued efforts. The nervous system is little affected by external impressions, while the mind preserves an exact analogy to the corporeal part of the frame, being denoted by the slowness with which impressions are made upon it, and the strength with which they are retained.

We may readily conceive that these differences in the physical constitution and powers of the system must be productive of considerable effect upon the generation of disease; that each temperament will be peculiarly liable to be affected by certain complaints, and that both their degree of violence and their permanence must be much influenced by the prevalent disposition of the body. The sanguine temperament, where the blood-vessels are distended and irritable, must be prone to all those affections which originate from the velocity of the circulation; the phlegmatic will lay the foundation for those diseases which arise from a languid condition of the secretory organs; the choleric, although perhaps the least obnoxious to morbid action, may be conceived to be more subject to derangement of the nervous system; and the melancholic to all those irregularities which depend upon a want of sufficient activity in the vital powers. The immediate production of disease, however, generally depends upon some extrinsic circumstance; and according as the diseased action coincides more or less with the natural tendencies of the system, so will be its degree of violence, in proportion to the magnitude of the exciting cause. An individual of a phlegmatic constitution may experience an attack of fever; but it is probable that the attack will be less violent, and the symptoms less obstinate, than in one whose circulation is habitually quick, and is easily thrown into irritation and excessive action. On the other hand, a certain state of the circulation, and of the absorbent system, which induces dropsy, may occur in the sanguine temperament; but it is to be supposed that this peculiar action will be more liable to attack the phlegmatic constitution, where the languor of the circulation is less able to counteract the accidental derangement which it may experience, and where the feebleness of the absorbents is less adapted for removing any morbid deposition of the fluids. The energy and activity of the choleric temperament must render it more subject to what are usually styled nervous diseases, while the contrary state of diminished activity, and want of sensibility in the melancholic temperament, will lay the foundation, or produce a disposition to those diseases, which originate in obstructions of the abdominal viscera, and diminished action of the different organs which are subservient to the process of nutrition.

Besides these characteristic traits, which attach to great numbers of persons, and manifest themselves in their habits and constitution, there are certain peculiarities, belonging to individuals, which exist only as it were in an insulated manner, having little or no apparent connexion with each other, or with the general condition of the system; these are called idiosyncrasies. They appear frequently to originate from hereditary descent; sometimes they apparently arise from mere accident, and are occasionally, as far as we can judge, the effect of whim and caprice; but, whatever be their source, they produce a powerful effect upon the constitution, and especially manifest themselves in the operation of medicines; so that it becomes an indispensable duty for the practitioner to make himself acquainted with them, and to apply his remedies accordingly.

We have hitherto been considering those causes of disease which enter into our original constitution; but, independent of these congenital differences, there are peculiarities which belong to the two sexes, and to the successive periods of life, which are no less important to be borne in mind. The sexes have each of them functions peculiar to themselves, and there is a well marked character in the formation of the body and its physical condition. The female approaches more to the sanguine and phlegmatic temperaments, the male to the choleric and melancholic; and this resemblance is to be observed in the diseases to which they are liable, no less than in the formation and powers of the body. The same remarks apply to the different ages of the same individual, which are denoted by certain peculiarities, that are no less important in influencing the phenomena of disease. The diseases of infancy are different from those of manhood, and these again differ from those of old age; and these peculiarities extend to all the powers and functions of the system, both physical and intellectual, to the nature of the morbid affection, and to the operation of remedies in its removal.

Thus far we have considered those circumstances, which are entirely independent of external influence, and which arise solely from internal causes; we must now consider those which originate from the conjoined operation of the two, where an accidental occurrence has intervened in the first instance, and has generated a peculiar disposition, which afterwards becomes connected with the general habits and character of the constitution. To this head are to be referred the effects of education and modes of life, and also those induced by different trades and occupations. It will not be necessary to enter into a minute detail, to prove that the operation of these circumstances must be very powerful. The constant influence which they exercise over the system, although at each successive moment of time it be slight and almost imperceptible, produces by its continuance the most permanent effects, and sometimes appears almost to counteract or pervert the original tendencies of the constitution. In no small degree even the national character of the whole community may be affected by its prevailing habits and accustomed employments. In the early stages of society, while the manners are simple and laborious, we observe a very different state, both of body and of mind, from what occurs in the same country at a subsequent period, when luxury and civilization have advanced to a high pitch of refinement, and when a large portion of the people are engaged in sedentary trades and professions. Even temporary fashions and customs in dress and diet have an important effect upon the constitution in general, as well as upon the production of certain diseases. To the substitution of cotton for woollen, which has taken place in this country, and to the less quantity of clothing which is employed by the females, have been attributed, not without a degree of plausibility, the greater frequency of pulmonary complaints; and it has been found, that the increase and decline of certain diseases of the abdominal viscera bear a pretty exact ratio to the greater or less employment of ardent spirits. No one can be ignorant of the degree in which gout is originally produced, and subsequently kept in action, by the habits of life; so that while it is almost a constant attendant upon a certain rank, it is very nearly unknown among the lower orders of society. It has been supposed, upon apparently good grounds, that insanity has become more frequent in this country; and it is not unreasonable to conclude, that it may be attributed to the greater mental activity and eagerness of the people in their pursuits, especially to the excessive spirit of mercantile speculation, and the sudden elevations and depressions of fortune, which are the necessary consequence of this system. The same tendency to mental diseases was observed to prevail in France, during the period of the revolution. An improvement in the modes of life, with respect to external neatness and accommodation, has been productive of very perceptible effects upon the health of great cities, where, not more than a century or two ago, certain diseases were very prevalent, which have now entirely disappeared. And, among the people at large, the same exemption has taken place, as far as respects some of the most loathsome cutaneous affections; a change which must be attributed, in a great measure, to the increased attention to personal cleanliness, and perhaps, likewise, in some degree, to the use of a more salubrious diet.

We have enumerated among the predisposing causes of disease, certain changes which may be produced on the constitution by accidental circumstances. This may be observed, both as affecting individuals or whole communities. Many children of a robust frame of body, and with all their faculties in an active and perfect state, by the occurrence of a malignant small-pox, have had the powers, both of body and mind, reduced to a state of irremediable weakness, which has continued through life; and it is perhaps not an unreasonable expectation, to anticipate a favourable effect upon the health and vigour of the people at large, when this loathsome disease shall be entirely extinguished by the substitution of the vaccine inoculation.

The circumstances which we have hitherto mentioned, as influencing the nature of disease, are to be referred, in the first instance, principally to the physical condition of the body, or to those powers which are immediately derived from it; but there are others connected with the intellectual functions, which are almost equally necessary to be attended to, from their power in producing diseases, and the manner in which they modify their phenomena. Among the most important of them, we may mention habit, association, sympathy, imagination, and, above all, the passions. To whatever cause we may refer the ultimate operation of the mental faculties, whether to some particular affection of matter, or to an immaterial principle, possessed of specific properties, it is certain that they all act through the medium of the nervous system. There are some cases, in which a morbid affection appears to be originally generated by an action excited in the brain and nerves, either immediately producing some change on those organs, or reacting on the heart and arteries; and, in many instances, a diseased state is kept up by the nervous influence, after the original derangement is removed. Although, therefore, the passions are to be regarded primarily as mental phenomena, yet they have a very obvious connexion with the physical part of our constitution, and produce upon it the most important, and even indelible, impressions. It has been observed, that particular passions exercise their influence more especially on particular organs of the body; some of them affecting the lungs, others the stomach, and others the bowels; and there is a mutual and reciprocal action between the mental and physical functions; so that, while a certain condition of the organs predisposes to certain passions, the prevalence or violence of certain passions induces a particular condition of the organs. In this place, it will be sufficient merely to point out a circumstance, which will receive many illustrations in a subsequent part of this article.

One of the most remarkable of the incidents, which belong to the animal frame, is the alternation of sleep and waking; a certain proportion of repose is absolutely necessary to the continuance of our functions in their perfect condition, and to repair the waste which is perpetually going forwards in the system by their several actions; while the state of sleep, if too long protracted, has almost an equally unfavourable effect. Irregularities in this respect are not only the usual attendants upon disease, but they are frequently one of its causes; and according to the habits of the individuals, either as induced by their occupations and modes of life, or as the result of purely accidental circumstances, are we to ascribe many of their constitutional peculiarities. A still greater effect may be attributed to the power of exercise, as well in the general state of the system, as in the production or prevention of disease. A due proportion of exercise we find to be necessary to the perfect action of every function, both of body and of mind; by its excess, they are exhausted, and fall into premature decay; while, by the want of it, their vigour is impaired, the body becomes incapable of maintaining itself in health, and the mind partakes of the languor and inactivity of the body. Although each extreme may be perhaps equally injurious, yet the greater number of diseases, that fall under our inspection, originate from this latter cause; and its first effects are generally manifested upon the functions that are subservient to the nutritive system. By this means the body loses its proper supply of matter, and both its physical constitution, and its vital powers, are immediately affected. The secretions of all kinds become deficient in quantity, and changed in their quality; the circulation proceeds with a languid current; and consequently both the muscles and the nerves are deprived of their due proportion of arterial blood, to support the contractility of the former, and the sensibility of the latter.

Besides the effect that is produced by a want of exercise, the secretions of all descriptions are subject to irregularities from other causes of various kinds, some constitutional, and others purely accidental, which lay the foundation for other morbid changes in the system, and become the source of both general and specific disease. The irregularities may be of three kinds, excess or defect in quantity, and a change of quality: it is obvious that their number may be very great, and the effects which they are capable of producing, by their variety of combinations, very considerable. They will however fall more properly under our notice, when we treat of the diseases which are the immediate consequence of these irregularities, or are intimately connected with them.

We have now taken a general view of the effect of the constitutional causes of disease, and also of some which possess an intermediate nature between the constitutional and those which depend altogether upon external circumstances, all of which must be regarded as, in most cases, rather predisposing to the morbid affection, than actually producing it. We must next consider the causes which we have styled extrinsic, which operate more directly in exciting disease; they may be referred to seven different heads—contagion, irregularities of temperature, peculiar states of the atmosphere, noxious vapours, climate, diet, and accidents of all kinds.

Contagions of various descriptions are universally recognized as producing some of the most violent and fatal diseases to which the human frame is incident. The manner in which they operate is probably different in different cases; sometimes they seem to act, in the first instance, upon the animal powers, diminishing their energy, and producing a tendency to the direct extinction of life. At other times, they appear to exert their influence more upon the physical part of the frame, producing an alteration in the condition of a single part or individual organ, so as to interrupt some necessary function, or to induce a secondary or consequential disease, perhaps more dangerous in its tendency than the primary one. There is also a third kind of contagion, which seems to act in a different manner from either of the two former. The first effect is probably local, and some time elapses, after it is received into the system, before it is perceptible; but its operation soon becomes general and constitutional, and it acts rather by the derangement or extinction of the vital powers, than by any physical disorganization of particular parts. We may adduce the contagion of typhus as an example of the first, of syphilis of the second, and that of small-pox as belonging to the third species. The immediate agent in the production of contagious diseases, the mode of its original generation, and the manner in which it is actually conveyed from one individual to another, have been the subject of much controversy, and much yet remains on all these points, of which we are unable to afford a satisfactory explanation.

The nature of contagion differs in different diseases, no less in its obvious nature than in its effects. It is sometimes a substance perceptible to the senses, formed by a process analogous to secretion, which communicates its effects only by contact, or when a proportion of it is applied to the body of another individual. There are other cases of contagious diseases, in which we are not able to demonstrate the presence of any one combination of elements, composing a substance possessed of peculiar or specific properties, but where the body seems to have experienced some change in its physical or chemical state, so as to emit certain exhalations or vapours, which, when received into the lungs, or perhaps even applied to the surface, produce a similar morbid affection. The first class of contagions act with more certainty, and generally with more virulence, and are capable of affecting the body without the concurrence of any predisposing cause, while the latter, for the most part, seem incapable of exercising their power, unless upon a system which is already prepared for their reception.

One of the most remarkable circumstances respecting contagions is, the property which some of them possess of attacking each individual once only in the course of his life. A change is thus wrought in the system, which is not cognizable by the senses, and it is remarkable, that the same change is effected, in however slight a degree the morbid affection may have been experienced. In one instance, that of the small-pox, the change is capable of being brought about by the occurrence of a different disease; one morbid affection, in this manner, permanently altering the condition of the body, so as to render it insensible to the operation of another contagion. In diseases which occur only as the result of a specific infection, it has been asked, How did the complaint originate? a question to which, it must be confessed, that it is very difficult to give a satisfactory answer. It has indeed been asserted, that no new contagious diseases are ever generated, but that they all existed from the first ages of the world, and remained confined to some remote districts, when, by war and conquests, or by other great political revolutions, by commercial intercourse, or even by the accidental visits of travellers, the poison became disseminated over a great part of the surface of the globe.

It is not easy to adduce any decisive arguments on the question; but it may be observed, with respect to the opinion that supposes the diseases to have remained in the confined or even latent state, that it in fact only removes the difficulty to a greater distance of time, without actually affording any proper solution of it. It is impossible to suppose that the original parents of mankind could have been born with all the diseases upon them, and it is as easy to conceive of their production at any subsequent period as in their persons. All that we are able to conclude upon the subject is, that certain concurring causes seem to generate contagions, which, when once generated, are kept up by the mutual intercourses of society; but with respect to their particular mode of generation, or the length of time that they have subsisted, we have very little positive information. As we are thus incident to a train of evils, which have probably been gradually increasing in number since the original formation of the human species, and which may still increase to an indefinite extent, so, on the other hand, it is probable that various circumstances are gradually operating to destroy those which already exist. Some of them appear to be incompatible with each other; the fatal effects of some are counteracted by the discovery of appropriate antidotes, while there appears to be a tendency to the gradual destruction or diminution of the whole of them, by circumstances connected with the progress of civilization, or with the combined result of a number of moral and political causes.*

The effect of temperature upon the animal frame,

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* The frequent occurrence of epidemic and pestilential diseases in the United States, of late years, has led American physicians to pay much attention to the nature of contagion; and in the investigations which have taken place, a degree of learning and practical sagacity has been displayed, highly honourable to the medical character of the country. The writer in the text very properly recognizes contagion as an important source of disease, and has offered a striking and somewhat novel view of the manner in which the different kinds of contagion operate on the human frame. To that modern scepticism, which denies the existence of the contagious principle in certain febrile disorders, may be opposed the uniform current of the highest authorities, from the earliest to the latest times. True it is, that though the ancients regarded the air itself as the frequent cause of epidemic disorders, yet there were not a few of them who considered contagion in the modern acceptation of the term. Thucydides, in his account of the plague of Athens, states explicitly, that persons caught the complaint from attending upon each other; Lib. ii. Aristotle seems to give countenance to a similar opinion: though the air might be the medium of spreading diseases, still a principle like that of contagion accompanied, according to him, certain morbid affections. He notices the contagion of plague; Prob. I: And, from the following extract, it is evident that Galen, while he admitted the influence of a peculiar condition of the atmosphere in the production of plague, maintained, at the same time, that that disease might be communicated by personal intercourse alone. "Et quidem quod aëris pestilens febrem afferre consuevit, nemo sanæ mentis dubitavit, sicuti et pestilenti morbo laborantium *conversatio periculosa, ne inde contagium contrahatur*, quemadmodum ex scabie et lippitudine."—*De Differ, Febri, lib.* i. Moreover, in the narratives of the ancient historians, and in the allusions of the classical poets, there is an evident recognition of this principle, as a matter of popular belief. See Livy, Sallust, Tacitus, Ovid, Lucretius, &c. It was not, perhaps, until about the middle of the sixteenth century, that the contagious nature of the plague became a subject of controversy. While a few contended, that its epidemical nature was owing to some occult constitution of the air, a great majority of that age adhered to the more ancient doctrine. Within the last century, this doctrine has been the subject of still more animated discussion, and opinions still more diversified have been promulgated; yet the mass of evidence and weight of authority are powerfully in favour of its specific character, and communication from one person to another. To a mistaken conception of the theory of Sydenham, in relation to epidemic diseases generally, and its undue application to certain specific disorders of a different nature, much of this diversity of opinion may be attributed. The limited sphere of the operation of contagions, even of the most virulent kind, and the peculiar laws which characterize them, (see the experiments of Dr. O'Ryan of Montpellier, on small-pox, and of Dr. Haygarth on scarlet fever,) appear to have been overlooked, and the most indubitable facts have given place to the gratuitous supposition of an *atmospheric poison, a pestilential constitution of the atmosphere, a new kind of air, a secret condition of the air, and a diminution of the exciting power of the atmosphere*, as in the writings of Adams, Bancroft, Smith, Webster, Maclean, and others.

Much light has unquestionably been thrown on the subject of contagion and febrile infection by American physicians. It was not, however, until the year 1796, that an attempt was made to establish a distinction between contagion and infection, and to arrange the diseases arising from these two sources. The author of this distinction, was Dr. Richard Bayley, an eminent practitioner of New York, whose views on this subject have been widely circulated in his own country and in England, and procured for him much reputation, though unfairly assumed as his own, by Dr. Adams of London. (See Bayley's Treatise on the Epidemic of New York, in 1795, and Adams on Epidemics.) In 1796 and 1797, Dr. Mitchill, the Professor of Botany and Materia Medica in the University of New York, published his Doctrines on the Pestilential Fluids, usually denominated the Theory of Septon. (See Duncan's Annals of Medicine, and New York Medical Repository.) In 1804, the late Dr. Edward Miller, of New York, communicated to the public an Essay, entitled An Attempt to deduce a Nomenclature of certain Febrile and Pestilential Diseases from the origin and nature of their remote cause. The miasma which excites yellow fever, and all the inferior grades of disease, termed remittents and intermittents, Dr. Miller contends, is emitted from dead animal and vegetable substances, immersed in a certain degree of moisture, and undergoing decomposition by means of solar heat. Hence, he observes, these diseases are found in the neighbourhood of low and swampy grounds, known to abound in this kind of filth, at that season when such filth is powerfully acted upon by heat; or they are found in large and crowded cities. On the other hand, the miasma of typhus, while it bears an obvious relation to that just described, exhibits also many important differences. Typhus, says Dr. M is generally, and it is believed always, originally the pestilence of poverty, of low life, of crowded habitations, of personal and domestic filth. In the evolution of the miasma of typhus, the matter of perspiration, and generally of all the excretions of the human body, constitutes the material, and animal warmth supplies the degree of heat necessary to set loose the poisonous gas. In order to distinguish these two *miasmatic atmospheres*, the author resorts to the Greek language for suitable terms. "That portion of air charged with miasmata exhaled by solar heat from the surface of swampy grounds, or from masses of filth overspreading the open area of cities," to use the author's language, is denominated "*atmosphæra koino-miasmatica*:" "that portion of air contaminated by miasmata emitted from and surrounding the body, clothes, bedding, and furniture of persons immersed in the filth of their own excretions, and of those associated in the same family with them, accumulated, long retained, and acted upon by animal heat, is denominated *atmosphæra idio-miasmatica*. Or, in other words, the koino-miasmatic atmosphere is that which is derived from a common or public mass of putrefying matter, expanded to the solar influence; while, on the contrary, the idio-miasmatic is derived from a personal or private source, being produced from the filth of individuals and their habitations, and diffused around them only for a small distance." (See Dr Miller's views further, in the Medical Repository, vol. 7.)

In July, 1808, Dr. Hosack, in a letter to Dr. Chisholm of Bristol, England, proposed a new theory on the laws governing the com-may be considered as among the most frequent causes of disease, being the most extensively diffused, both through the different orders of society, and through all the different parts of the earth. Its pernicious effects depend either upon its excess, its defect, or its irregularities; the degree in which each of these causes operates being, in a great measure, regulated by climate, and local situation, modified by the habits and occupations of different classes of individuals. To understand the mode in which temperature operates in the production of disease, would require a complete knowledge of its effects on the vital powers, on the physical organization of the body, and on each of its functions—a knowledge which implies a thorough acquaintance with physiology in all its branches. We may, however, observe in a few words, that the exercise both of irritability and of sensibility is much affected by temperature, that it is totally suspended by a deficiency in this respect, and that although an increase of it, within certain limits, seems to excite those powers, yet, if the quantity be still farther augmented, it proves equally destructive. The physical properties of the component parts of the body are much influenced by the temperature in which they are placed, and beyond certain limits some of the functions most essential to life have their action completely deranged, or even entirely suspended. The body is incapable of subsisting, except its internal heat be kept at a particular standard, and one of its most curious and elaborate operations is that by which it actually generates or extricates caloric, for the purpose of maintaining this due degree of heat. The powers of the system in this respect are, however, limited, so that if the deficiency be too great, between the external temperature and that which is necessary for the support of the body, the calorific process is inadequate to supply the deficiency, and a suspension of the vital powers ensues. On the other hand, we find that the body is adapted to a temperature inferior to itself, and if the surrounding medium be heated to a much higher degree, the functions are destroyed, and a state is produced, which lays the foundation for some of the most fatal diseases. These effects of the extremes of temperature are observable, both on the body at large, and on its individual parts, and the diseases that ensue are to be attributed some of them to the immediate abstraction or accumulation of heat, while others are to be ascribed to some change produced by the primary operation of temperature, acting through the medium of some organ or function that has experienced its direct influence. Many of the diseases, which were conceived by the humoral pathologists to originate in an alteration in the state of the fluids, are now, with more probability, traced to the effects of temperature, and the same remark applies to the morbid affections of the nervous fluid or the vital principle, which have, at different periods, been held up by theorists as among the most frequent and active causes of disease.

Although the human subject is so formed, as to be capable of subsisting under a considerable range of temperature, and, to a certain extent, can accommodate itself to the changes to which it is subjected, from the variations of the atmosphere, and the necessary occupations of life, still this capacity has its limits, which cannot be passed with safety. Among the higher ranks of life, in this country, there is perhaps no causes of disease more frequent than those which arise, either directly or indirectly, from the irregularities of external temperature; and, according to the mode of their application, or the degree in which they exist, they may constitute some of the most acute, or the most certainly fatal diseases which occur in our climate.

The changes in the nature and properties of the atmosphere constitute the next set of causes, which we pointed out for the production of disease. From the period when the earliest observations were made in medicine, as well scientific as popular, we find a perpetual reference to these circumstances; but, while neither the physical nor the chemical qualities of air were understood, we cannot be surprised that the ideas which were entertained upon this subject were generally inaccurate, and that the effects were exaggerated. In the present day, however, when we are much better able to appreciate the relation of cause and effect in physical agencies, both from a more correct acquaintance

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munication of contagious and infectious diseases. (See the Edinburgh Medical and Surgical Journal, vol. 5) Those diseases which are communicable from one person to another, and are generally considered of a contagious or infective character, are distributed by Dr. H into three classes First, such as are communicated exclusively by *contact;* as itch, syphilis, sibbens, laanda africana, frambœsia, elephantiasis, variola, vaccina, and hydrophobia: secondly, such as are communicable by *contact* and the *atmosphere;* as smallpox, measles, chicken pox, hooping cough, scarlatina, and cynanche maligna: thirdly, those diseases generally communicable only in an *impure* air; as plague, yellow fever, typhus in its different forms, and dysentery. This classification seems to have received the approbation of many distinguished men in Europe. (See Annual Medical Review, vol. 2 Blane's Medical Logic. Chisholm's Letter.) The following extract contains an illustration, in part, of the principles upon which the last mentioned arrangement is founded.

"The visitor or attendant contracts disease from one of *two* sources; either from the filth of the sick room, or from a *specific* something issuing from the body of the sick, the consequence of the peculiar disease under which he labours. If a person, visiting another ill of the *yellow fever*, or *plague*, derives his disease from the *impure atmosphere* of the apartment, I ask how it happens that in all instances he contracts the *same* disease with that of the person whom he visits? Why is his disorder not an *intermittent*, a *remittent*, *jail fever*, or *dysentery*, which are considered the usual produce of filth? If he derives any thing specific from the sick, his disease is then assuredly not to be considered as occasioned by the atmosphere, but depending on the peculiar condition of the fluids or state of the system, induced by the action of a specific poison; in other words, it is to be considered a *contagious* disease The distinction proposed by Dr Bayley, inasmuch as it does not account for the communication of the *peculiar* form of fever or disease which is thus propagated, I therefore consider to be insufficient to account for the circumstances attending the communication of those diseases to which it is applied. That I may not be misunderstood, I will suppose A to be ill of dysentery, a disease well known to be attended with a *peculiar* train of symptoms; he is in a small, confined apartment, his person is neglected, the atmosphere around him is rendered impure and offensive; under these circumstanees B visits him, and, a few days after, is also taken sick with the *same* disease, attended in all respects with the *same* dangerous symptoms which characterize the disorder of A. Dr Bayley, and those who adopt the doctrine of *infection*, as opposed to *contagion*, consider the disease of B to proceed from the *impurities of the air of the chamber*, and not from any thing *peculiar*, emanating or secreted from the body of A. But as we may, without hazard, visit an equally filthy chamber, where C lies ill of *cholera morbus*, or D with a *broken limb*, I therefore ascribe the disease of B to something more than the impure air of the chamber of A. I ascribe it to a *peculiar virus* generated in his system by the disease under which he labours, and communicated by his excretions to the surrounding atmosphere, rendering it thus capable of producing the *same* disease in those who may be exposed to its influence." See Transactions of the Literary and Philosophical Society of New York, 4to, vol. i.

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with the nature of the agents, and from more accurate ideas upon philosophy in general, we cannot doubt of the morbid operation of certain states of the atmosphere, and of its power in generating disease; yet it must be confessed, that we are in many cases unable to account for the nature of the operation, when we are obliged to admit its existence. We have now acquired a correct knowledge of the chemical composition of the atmosphere, and we are aware of the changes to which its physical properties are incident; and we frequently observe effects upon disease, which can scarcely be referred to any agency, except that of the atmosphere, where, however, we find it extremely difficult to determine in what manner the operation can be brought about. There are, what have been styled, certain epidemic constitutions of the air, which seem obviously to be connected with the production of certain diseases; yet where neither the chemical qualities of the atmosphere, its state of moisture, its gravity, its temperature, or any other of its sensible properties, are so far affected, as to afford any rational explanation of its mode of action.

The ancients and the earlier of the modern writers, having paid little regard to the operation of the vital powers in the production of disease, were on this account naturally led to attend more to the agencies of external causes; and the atmosphere, presenting one of the most obvious means by which the body might be supposed to be affected, almost all diseases were conceived to be more or less under its influence. This led to the doctrine of *occult causes*, a doctrine which seemed to be sanctioned by the facts in question, and which entirely coincided with the opinions of the age. In a later period, when the mechanical system of medicine was generally adopted, the physical properties of the atmosphere were applied, according to this hypothesis, to explain its effects upon the body; the tension and relaxation of the fibres, the distension and compression of the vessels, the acceleration and retardation of the motion of the blood, and the other circumstances which were regarded as the primary cause of all morbid actions, were referred to the changes which occurred in the quality of the air. When we come to treat concerning individual diseases, we shall have occasion to inquire, in each particular case, how far the different states of the atmosphere can be supposed capable of producing them in the first instance, or of affecting their nature and symptoms

Nearly allied to the effects which arise from changes in the state of the atmosphere, are those which depend upon the diffusion of noxious vapours or exhalations through it, by which we mean extraneous substances not forming a part of its proper constitution. These vapours are to be regarded as among the most efficient causes of disease, both with respect to their frequency and their virulence. They may be arranged under two divisions, according as they are the immediate cause of specific diseases, or as they produce an unfavourable effect upon the system at large. In the first class are to be placed some of the contagions that are generated by the animal body, and the effluvium of marshes: the former producing continued fevers, the latter those of an intermittent type. The vapours of the second species, which rather give rise to a general state of ill health, than to any immediate specific disease, are very various in their nature and origin. Among these, we may place the atmosphere which hangs over great cities, composed, in a great measure, of the smoke that proceeds from burning fuel, exhalations from putrid animal and vegetable substances, those which arise from chemical manufactures of all kinds, and likewise the noxious effluvium which seems necessarily to emanate from the animal body, when it is confined in close and unventilated apartments, and has its operation promoted by a want of personal cleanliness. There are certain vapours which seem to possess properties of a specific nature, some of which may be referred to their chemical agencies, while in other cases we are unable to account for the precise mode of their operation, although there can be no reasonable doubt of the reality of the effect.

Many of the diseases to which the human frame is incident, are to be attributed, either directly or indirectly, to the nature of the substances used in diet. Besides those bodies, which may be considered as properly subservient to nutrition, such as are actually capable of producing chyle, there are a variety of matters, both solid and fluid, that are received into the stomach, merely in consequence of their agreeable flavour, or their grateful effects upon the system, forming altogether a most heterogeneous, and, not unfrequently, a most pernicious compound. The effects of these irregularities are experienced, not only in the stomach itself, but in all the functions both animal and vital, so as to derange the harmony of the whole, and to lay the foundation for diseases of particular organs. Next to the effects of temperature, there are no causes which are more frequently productive of disease, in a highly civilized state of society, and especially among the superior classes, than those which originate from the digestive organs. A requisite supply of nutriment being absolutely essential for the exercise of the functions, they may suffer as well from defect as from excess, but of the cases in which medical aid is required, a very large proportion proceed from this latter cause. We shall likewise find, that independently of any error in the nature of the food employed, the habits and occupations of a large proportion of the individuals that compose the different classes of society, are unfavourable to the healthy action of the stomach and bowels, so that, without the occasional aid of medicine, or of other means expressly employed for the promotion of health, the functions of these parts become deranged, and the whole system sympathizes with their morbid condition. Hence, the diseases that are the consequence of an irregularity in diet may be divided into two great classes; first, those which depend upon the effect immediately produced on the organs belonging to the nutritive system, the stomach, the intestines, and the absorbents, to which may be added the liver, the spleen, and the pancreas; and secondly, diseases of the sanguiferous or nervous systems, operating through the medium of some of the parts mentioned above, but manifesting their effects principally on the state of the circulation or the animal powers.

Diseases are frequently referred to the effect of climate, and there can be no doubt of the very powerful influence which it exercises over the constitution, or of the serious derangements which often occur as its apparent consequence in many of the most essential functions. In a technical classification of the extrinsic or exciting causes of disease, it may however be questioned, whether climate can with propriety be introduced among the primary divisions; because its operation must be regarded as resulting from the combined action of several circumstances, which have each of them been already considered. The chief circumstances which co-operate in this case are, temperature, the state of the atmosphere, diet, and particular modes of life, besides which, it is not easy to conceive of any others which can produce a very notable effect. At the same time, it must be acknowledged, that there is no subject of greater practical importance to be attended to than climate, and that, although we feel no doubt about the ultimate cause to which its action is to be referred, yet we find, that the aggregate of these causes operates in a specific manner, which occasionally differs from what might have been previously expected. This remark applies more immediately to hot climates, for although certain states of disease are as obviously induced by a diminished, as by an increased temperature, yet the former seem to be of a more simple nature, and are more easily produced by the ordinary laws which direct the animal economy.

Respecting the last division of the extrinsic causes of disease, accidents of all descriptions, it is not necessary for us to make many general observations. Their nature is, of course, as various as the circumstances producing them; and the only point which they have in common, and which requires to be borne in mind by the practitioner, is their being more or less local, and what follows from this, that, within certain limits, the derangement of the system is entirely consequential to that of the affected part. Under the head of accidents, are to be included the effects of external violence, such as cuts, bruises, and lacerations; poisons taken into the stomach, or corrosive substances applied to the surface; strains and over-distention; and violent compression. Besides these mechanical operations, which are, in the first instance, entirely confined to the part immediately acted upon, there are other circumstances of a more general nature, which might properly come under the designation of accidents, such as fits of intoxication, and even unusual repletion of the stomach; but as they induce a constitutional disease of a specific kind, they are arranged according to their effects, as the exciting causes of the different diseases which they produce.

After these observations upon the general nature of disease, and upon the causes which produce it, there are yet some remarks, of a more miscellaneous kind, that remain to be offered, concerning the effect of diseased action upon the system at large. The different parts of the body, and its various functions, are so intimately connected together, that no considerable alteration can take place in the state of any one organ, without communicating some change to all the remainder; and we accordingly find, that as the secondary disease coincides with, or opposes the primary affection, so is the morbid state either aggravated or diminished. And besides the actual production of what may be called the consequential disease, it is often observed that one deranged action generates a predisposition to others, so that they really lay the foundation for, or become the remote cause of, each other. There are some diseases which seldom make their appearance in the first instance, but are generally consequential to some other complaints; thus phthisis pulmonalis generally succeeds to catarrh or pleurisy, and ascites is often preceded by an organic disease of some of the abdominal viscera.

A circumstance occasionally takes place, which is not a little singular and difficult to account for, where a disease which has existed for some time entirely disappears, and is immediately succeeded by another, to which it has no apparent relation: a remarkable example of this conversion of diseases occurs in phthisis, which has been completely suspended, if not entirely cured, by the supervention of insanity; a confirmed asthma, which has resisted all remedies, has been removed by a diarrhœa; and a disorder of the stomach is frequently removed by the appearance of a cutaneous eruption. It is upon a principle analogous, if not altogether similar to this, that many of our most powerful remedies may be supposed to operate. Mercury cures syphilis, as it is said, by its specific action; an expression to which we can attach no other meaning, but that the state of the system, induced by mercury, which constitutes an acute, and sometimes a dangerous disease, is incompatible with the disease of syphilis, or that the one affection is converted into the other. It is perhaps in the same way, that the inflammation of an internal organ is, by means of a blister, transferred to the surface, and thus eventually relieved; and it is probable that most medicines, which act upon the system at large, where their effects do not depend upon evacuation, are to be considered in the same light, as inducing a diseased condition of the body, which supersedes the former disease, and which is either less dangerous, or more within our power to suspend or remove. No one can suppose that the abstraction of a few ounces of serum from the vesicle of a blister, or of a little perspirable matter from the skin, can subdue a tendency to inflammation of the chest, by the bulk of fluid discharged, which bears so small a proportion to that of the whole contents of the vessels, but to a certain state of the circulating system, which is itself to be regarded as differing from the healthy condition, but which supersedes both the local and the general inflammatory affection, and which is unattended with danger, because it remains no longer than while the means are employed for its continuance.

Besides those peculiar changes or variations in the phenomena of disease which are more strictly entitled to the appellation of conversion, where an affection entirely leaves one part or texture, at the same time that the patient is immediately seized with an affection of some other part or texture. Dr. Parry has classed together a number of facts, where the diseases are not so properly converted into each other, as related together by a remote connexion. (*Pathology*, Sect. 860.) Of this kind are those cases where the patient, after having had one part affected, experiences the same morbid condition in another part at some future period, but where the two sets of symptoms have evidently a relation to each other. Among the cases of this description, we may adduce those where a patient is first seized with epilepsy, after some time with hemiplegia, and is finally carried off by apoplexy; where hæmorrhoids are superseded by vertigo or by gout, where gout is followed by acute asthma, and where, on the contrary, severe asthma is suspended, and finally relieved by confirmed gout.

Besides this conversion of diseases, or the power which they appear to possess of superseding each other, many of the most eminent pathologists, both ancient and modern, have attributed to the animal frame a principle of self-preservation, by which it both resists the tendency of external agents to produce its natural dissolution, and especially counteracts the progress of disease. A principle of this description has been recognized under various denominations, from the time of Hippocrates down to the present day; and, according to the respective hypotheses of the authors, has been dignified with a variety of properties and faculties, many of which are altogether fanciful and imaginary, and others entirely unsupported by accurate observation or correct reasoning. Among other pathologists of our own times, Hunter and Cullen have particularly employed this salutary power as forming a distinguished feature in their medical theories. In the former, it is distinguished by that metaphysical language, which he was so much in the habit of employing in the expression of facts, in which he confounds the relation of cause and effect, and substitutes the final for the efficient cause of phenomena. In the writings of Cullen it assumes a more philosophical aspect; and, although we may differ from him in the propriety of its introduction, and of its application, yet we must admit that his opinion is clearly announced, and that it possesses an intelligible form, to which we are able to affix a precise idea. According to this author, the animal system possesses a power of resisting those circumstances which tend to its injury or destruction; and when, from any external cause, a morbid action has been established, a certain natural power of the constitution is brought into action, and sets on foot a process of an opposite kind, by which the former is counteracted or superseded. (*First Lines*, Sect. 38.) This power, or *vis medicatrix naturæ*, as it is styled, if left to proceed in its natural course, and if it exist in the proper degree, without being either excessive or defective, is, in most cases at least, adequate to the cure of the disease; and the principal duty of the physician is to watch over the operation of this principle, and to follow the indications which it points out, promoting or moderating its efforts, when either too feeble or too violent. The instances in which an injury to a part of the body, or a derangement of any of its functions, manifests a tendency to its own reparation or re-adjustment, are numerous, and lie open to the most casual observations. A recent wound requires for its cure only to have the divided parts laid together, and to be defended from the air, or other causes of external irritation; a local inflammation produces effusion and suppuration, by which the unusual quantity of blood, or other fluid, is carried off, and the vessels suffered to regain their ordinary capacity. A febrile paroxysm goes through a regular process, and terminates by a removal of those symptoms which seem to constitute the essence of the disease; plethora relieves itself by hæmorrhage, while the hæmorrhage is again, in its turn, checked by the syncope which succeeds; repletion of the stomach is carried off by vomiting and purging, which likewise operate their own cure, by the discharge of the offending materials; and, in short, every morbid condition is said to have its appropriate means of cure, naturally implanted in the frame, and forming a part of its constitution.

Numerous facts of this description are admitted; but how are they to be accounted for, or in what language are they to be announced? Do they prove the existence of a specific principle; and are they all to be referred to the operation of any one agent? In order that a set of phenomena be considered in this kind of relation to each other, it is necessary that they should bear a close analogy, and that they should be capable of being generalized, in consequence of a number of common properties which they exhibit. But this state of things is not found to exist in the case under consideration; for what analogy or resemblance can we trace in the several actions enumerated above, between the mode in which a wound is reunited, a tumour dispersed by means of an abscess, the paroxysm of fever brought to a crisis, or plethora reduced by hæmorrhage? The truth is, that all those actions, so far as we are able to judge, originate from different sources, and depend upon different principles in the animal economy. The only common property which they possess is their ultimate purpose or their final cause; and the only general principle which they tend to illustrate, is the design which is visible in all the operations of nature, and which forms a part of the great plan of the universe. The reciprocal action of the atmosphere and of the constituents which compose the globe, that of the sea and land upon each other, the principle of chemical affinity, as affecting organized substances, and the laws of organized bodies, as affecting inorganic matter, all afford ample illustration of this mutual accommodation, by which various bodies, from the exercise of their powers, all contribute to the same general result. It is highly important and interesting to trace the connexion of these several actions, and to notice their final effect; but we have no ground for attributing them to any single efficient cause, which is either recognized by an analogy in the phenomena, or by our being able to refer them to a principle, which can be defined merely by its physical energies.

Nor is this to be regarded as a question of simple curiosity, or of abstract speculation. One of the most important medical doctrines that has ever influenced the schools of physic, both in ancient and in modern times, is the agency of the supposed principle of self-preservation; for, by admitting its existence, the office of the physician is reduced to that of simply regulating the efforts of nature, while he is prevented from interfering with them, or at least from counteracting them, however noxious they may appear, or however they may seem to be at variance with the healthy condition of the system. In the future part of this article, we shall have ample opportunities of pointing out the fallacy of this opinion, and of showing into what an inert, and sometimes even fatal plan of treatment, it must necessarily lead the practioner.

Another point that has been much agitated by pathologists, and which is intimately connected with the discussion respecting the preservative power of the constitution, is the question, whether all disease be not entirely an effort of nature, as it is styled, to relieve some morbid affection, and ought consequently to be regarded, not as in itself an injurious operation, but as tending to counteract some irregular action that had been already established? It is indeed little more than generalizing the individual facts which have been stated above; and, if we admit the existence of the *vis medicatrix* as a principle which may be employed to explain other phenomena, this idea respecting the nature of disease follows as a necessary consequence. The same objections, however, obviously apply to this definition of disease, as to the general doctrine of the agency of the preservative powers of the system; and, although there may be certain cases in which a morbid affection seems to be cured by some natural process of the system, yet they may be all referred rather to the general plan of adaptation, which pervades the whole universe, than to any thing specific in the phenomena of pathology.

There is a principle in the animal frame, or a peculiar mode in which its powers manifest themselves, which, in consequence of its influence over the production of disease, must be noticed in this place, to which the term of reaction has been applied. The name, although in some measure metaphorical, may be regarded as not unaptly designating its nature, as it consists in a certain tendency of the system to overcome the obstacles that are opposed to its operations, and even to increase the effect, in proportion to the magnitude of the resisting force. A familiar and a correct illustration of the nature of reaction is taken from the effect of cold upon the extremities. When the hand is exposed to a low temperature, the capillary arteries no longer receive their usual supply of blood, the surface consequently becomes pale, and the heat is diminished; but, after a certain period, the vessels act with an increased power, so as not only to restore the ordinary degree of warmth to the limb, and to fill its arteries to their accustomed size, but in both these respects to exceed the standard of health; the blood vessels are rendered turgid, the heat is increased, the sensibility becomes acute, and the part is brought in a condition, which, under ordinary circumstances, completely counteracts the operation of the external agent. This principle of reaction may be observed in almost every part of the system, influencing our functions in a variety of ways, frequently repelling the noxious effect of extraneous bodies, but, on many occasions, laying the foundation for disease, or aggravating it when it previously existed. As the principle is in itself a natural, and even a necessary part of our constitution, its farther development, as well as an inquiry into its causes and mode of operation, belongs to the physiologist; but, in the subsequent part of this article, when we come to the consideration of particular diseases, we shall have many opportunities of observing its effect, both as tending to prevent or alleviate them in some cases, and in others, on the contrary, as producing or increasing them, while we shall have frequent occasion to notice its action, when we examine the intimate nature of diseases, and trace the connexion between the various morbid phenomena.

The principle of reaction forms a very distinguishing feature in the pathology of Dr. Parry. Although under a different denomination, this ingenious physician adopts, to a considerable extent, an opinion similar to that which we have mentioned above, respecting the salutary tendency of many of the operations of the system; he differs, however, from Cullen, and other preceding writers, in one essential particular, that he refers these actions, not to the agency of any one power or faculty, or indeed to any one law of the animal economy, but rather to the general system of the adaptation, or the adjustment of different processes to each other, which forms so essential and conspicuous a part of the constitution of a living body. What Dr. Parry calls the "salutary processes" are of two kinds; those which terminate or consist in evacuations, where the effect is more direct and obvious, and those in which the salutary process consists in some kind of reaction. To the operation of this power many circumstances are referred, which, at first view, would not appear to have any connexion with it; not only is inflammation regarded as one of the reacting processes, instituted for the purpose of relieving local congestion, but, on the same principle, he accounts for the shivering which exists in the first stages of intermittent fever, during the formation of pus, and the passage of a gall stone along the biliary ducts. The shivering, in all these cases, is regarded as a modification of exercise, the ultimate object or final cause of which is, to restore circulation and heat in a part which has been deprived of its due share of vital action. To the same system of causation are referred the convulsions of hysteria, and even of epilepsy, which are regarded as salutary processes for relieving the excessive determination of blood to the brain, and propelling it along the veins. Upon the same principle, fever is considered to be a salutary process for relieving the arterial system generally, and gout that of the digestive organs in particular; in the first case, to produce a more equable distribution of the blood through the different parts of the sanguiferous system; and, in the latter case, to send the superfluous or excessive proportion of blood from the stomach and bowels to the extremities. Hence the author draws the important conclusion, which irresistibly follows from the premises, that, by curing certain diseases, we frequently shorten life. (§ 880, 1007.)

After the consideration of the nature and causes of disease, we next proceed to that branch of the science which gives an account of the symptoms. According to the original meaning of the term, symptoms may be defined those events or circumstances, which, when connected together, constitute a disease; but the modern acceptation of the word is somewhat different; and by symptoms we now generally mean, not the change in the system which actually takes place, but certain phenomena which serve to indicate the nature of these changes. In enumerating symptoms, we do not state all the occasional deviations from health which occur in any of the functions, but some characteristic points only, perhaps of secondary importance with respect to the affection of the system, but which are peculiarly striking, or lie more immediately under the cognizance of the senses. Hence the chief object of symptomatology is to enable us to form a correct diagnosis between diseases which generally resemble each other, and are liable to be confounded together. Thus, in describing the symptoms of typhus, we do not enter into a consideration of the internal changes, which either produce or actually constitute the disease, but of the condition of the pulse, the temperature of the surface, the state of the digestive organs, of the sensations, and the secretions. In enumerating the symptoms of pleurisy, we do not think it necessary to enter into an account of the intimate nature of inflammation, of the change in the vessels which constitute this action, or of that produced upon the contents of the thorax; we are satisfied with pointing out the sensible effects of the disease, as ascertained by the feelings of the patient, or by the observations of the physician. According to this view of the subject, it follows that symptoms may be arranged, so far as respects the operation of the system, into those which depend upon a change in the functions, in the structure of any part of the body, or in the sensations. Symptoms are therefore to be considered as something distinct from the disease itself, the disease being an alteration that is induced in a part of the system, which is frequently obscure, and beyond our power to comprehend, while the symptoms are the manifestation of this change, and, from their very nature, lie open to our observation. The cause of the disease, the disease itself, and the symptoms, are therefore the objects of separate consideration, and are not to be confounded together in viewing the phenomena of morbid action.

Writers on pathology have arranged symptoms under different classes, according to their supposed relation to each other, or to the cause producing them. They have been distinguished as of three kinds; first, the symptoms of the disease itself; secondly, the symptoms of the cause of the disease; and, thirdly, the symptoms of the symptoms themselves. This division has some foundation in fact, although it may be thought to savour too much of the scholastic method of considering questions of science, and to be rather nominal than real. Many of the morbid phenomena, which have been considered as symptoms by some authors, have by others, perhaps with more propriety, been regarded as secondary, or consequential diseases; and, in point of practice, they are as much the objects of direct attention as the affections, which are conceived to be more immediately connected with the actual change in the system. In the same manner, the division of symptoms into primary or essential, and secondary or accidental, although it may have a real foundation in the nature of things, is frequently not to be maintained; and, in most instances, it will be found extremely difficult to determine to which class each individual symptom is to be referred.

We frequently meet with the terms diagnostic and pathognomonic symptoms; by the first of which we understand those which serve to characterize a disease, and distinguish it from one which, in most respects, nearly resembles it; and, by the latter, those which are peculiar to a disease, and enable us to ascertain its existence, without reference to any other morbid affection. The former is consequently of more general application than the latter; every diagnostic symptom must necessarily be pathognomonic; but there are some pathognomonic symptoms which are not properly diagnostic. The correct investigation of these circumstances constitutes one of the most important parts of the duty of the practitioner, and forms the basis upon which all his future plans of treatment are to be founded; until we have clearly determined what is the disease with which the patient is affected, our remedies must be applied at random, and our speculations concerning its cause or its nature must necessarily be vague and indistinct.

The third branch of pathology is that which treats of the signs of disease, or those circumstances connected with their phenomena, which enable us to predict their probable termination. It is styled semeiology, and is distinguished from symptomatology, in as much as the latter professes only to judge of the present state of the morbid affection, while the former enables us to foresee the future changes which it is to experience. The signs from which we endeavour to form our prognosis, differ from symptoms rather with respect to the use that is made of them by the practitioner, than by any thing essentially connected with their nature; the term symptom may indeed be regarded as a generic expression, including the whole, while that of sign is restricted to a specific description of symptoms. A knowledge of the signs of disease is scarcely less necessary than that of the nature of the disease itself, and was one of those points on which the ancients exercised much of their skill. Some of the most valuable of the works of Hippocrates, and those the authenticity of which is regarded as the most undoubted, are principally devoted to this subject, and after all the improvements that have been made in medicine through a succession of so many ages, they still possess a degree of value which entitles them to our careful attention. The excellence to which the great father of physic brought this department of his art, almost at the very period of its creation, is to be attributed in part to the peculiar qualities of his mind, and to the unwearied assiduity with which he cultivated his profession. In part, also, it may be ascribed to the state of the science itself, which was yet but little encumbered with hypotheses, so that an ardent and sagacious student of nature had little upon which to exercise his genius, except the correct observation of phenomena. An account of the signs of disease also forms some of the most valuable parts of the works of Celsus, who indeed has borrowed very freely from Hippocrates, and in Galen we meet with much accurate observation on these topics, partly derived from his predecessors, and partly original; but as being more connected with his peculiar theories, it is less valuable than the simple aphorisms of the Grecian.

Although the principles from which we derive our general doctrines of semeiology are fundamentally the same with those of the other branches of pathology, and are, like them, ultimately to be referred to our knowledge of the functions of the living system, yet an acquaintance with the signs of disease depends more upon mere observation, and, to a certain extent, may be obtained without any consideration of the causes which produce them. On this account, it is difficult to lay down any general rules, which shall apply to all cases; yet it will assist us, in our investigation of signs, to form an arrangement of them, according to their connexion with the principles of the animal economy. They may be conveniently divided into four classes; those which depend upon an affection of any of the vital functions; those which depend upon an affection of the animal functions; those which are derived from any peculiar appearances in the excretions and secretions; and, lastly, those which originate from a combination of the former causes, or from some circumstances which produce a more general effect upon the body at large. In the first class, we may place all those points which are connected with the state of the circulation, the respiration, the action of the digestive organs, and the temperature, as manifested respectively by the condition of the pulse, the breathing, the stomach and bowels, and the heat of the body. Under the second division, we are to include all the changes in the nervous system, both physical and intellectual, either as producing what we usually style nervous affections, or more immediately operating on the mental faculties. These deranged actions of the animal functions may consist either in their excess, defect, or irregularity.

The altered condition of the secretions and excretions has always been regarded as among the most direct means of forming our prognosis; and from the age of Hippocrates, to the middle of the last century, they were among the circumstances that were the most minutely attended to. This proceeding, to a certain extent, must be admitted to have been correct, for there is no doubt that, from the changes which occur in the fluids, an accurate opinion may be formed, in many cases, of the changes that are likely to take place in the state of the disease. Yet, at the same time, we have reason to suppose, that much of the attention which has been bestowed upon these subjects depended upon the general prevalence of the doctrines of the humoral pathology, which regarded the fluids, not only as affected by diseases, and serving to indicate their nature, but as actually producing them by the changes which they experience. Still, however, it is universally allowed, that the sensible changes which take place in the secretions and excretions deserve to be minutely attended to, and frequently afford us the means of acquiring information respecting the nature of the disease, that could not be obtained from any other source.

In the fourth class of the signs of disease, we place a variety of circumstances of a miscellaneous nature, and consequently depending upon a variety of causes. Among the most important of these are the general aspect of the countenance, the peculiar state of the muscular and nervous powers, the emaciation of the body generally, or of particular parts of it, the colour of the surface, peculiar sensations in different parts, which are quite anomalous, and extremely difficult to be accounted for upon any correct principles of pathology; and many other circumstances, which will be stated when we come to treat of individual diseases. As has been already observed, those phenomena which are principally employed as signs, to assist us in our prognosis, are also symptoms indicative of the actual state of the disease, and are, at different times, more especially useful in one or other of these objects. We shall only farther remark, on this subject, that many of our most accurate prognoses are of what may be called a negative kind, being derived from the absence of certain circumstances, which are necessary to the healthy condition of the system, and which as clearly indicate a diseased action, as the presence of certain phenomena which are of a positively morbid nature.

CHAP. II.

Account of Pathological Hypotheses.

According to the plan which we proposed, we now proceed to give an account of some of the most celebrated hypotheses, which have prevailed at different times, on the subject of general pathology. Those which we shall particularly notice are four; first, the doctrines of the humoral pathologists; secondly, those of the solidists; thirdly, those of the spiritualists; and, lastly, the opinions of the modern vitalists. In this classification, it may be observed, that we have entirely omitted two sects, each of which, for a certain period, obtained the highest degree of reputation—the chemists and the mechanicians; an omission which we have made, because, whatever degree of reputation they might formerly have enjoyed, they are now totally discarded. And this has happened, not so much in consequence of their opinions having been gradually corrected, or their views extended, in proportion to the more accurate or enlarged notions which we have acquired respecting the animal economy, but because their doctrines are now universally allowed to have been built upon the assumption of a principle which was fundamentally erroneous. The pathologists, belonging to all the four sects, which are mentioned above, however they may differ in the detail of their opinions, or however dissimilar their final conclusions may be, still they all agree in appealing to the powers and functions of the living body, as the basis of their respective systems; and they all admit, that these powers depend upon certain properties peculiar to them, and which do not exist in any other natural objects. The chemists and mechanicians proceeded in a different manner. They supposed that the living body was possessed of precisely the same qualities with inanimate matter, and that, considered both as a whole, and with relation to its individual parts, its operations were exactly similar to what would have resulted from the action of the same mass of matter, endowed with the same physical properties. We are now convinced of the fallacy of this opinion; and every additional fact and observation tends to establish the contrary doctrine, that the living body has faculties peculiar to itself, and that although it is not exempted from the laws which affect inanimate matter, yet that they are of secondary importance only, and are not unfrequently either counteracted or suppressed by the former.

The doctrines of the humoral pathology composed the foundation of the first medical hypotheses with which we are acquainted; they are maintained by Hippocrates in all his writings; he seems to have received them from his predecessors, and he transmitted them to his followers, by whom they were implicitly adopted, with no important variation, until the time of Galen. Galen professed to be in all respects the disciple of Hippocrates; he set out from the same general principles, and pursued the same train of reasoning; yet he carried his speculations so much beyond those of his master, and entered so much more into minute detail concerning them, that he is always referred to as the standard authority on the subject of the humoral pathology. In our historical sketch, we have given a brief outline of the tenets of Hippocrates and Galen. We observed that they assumed, as the first principle of their hypotheses, and one which they conceived to be incontrovertible, that the primary change in all diseases is an alteration in the state of the fluids, connected with their supposed inherent properties, and the nature of their component parts or elements. It is not very easy to ascertain the origin of these opinions; they appear, in some measure, to have depended upon the sensible properties of the substances in question, but probably also, in no small degree, upon certain obscure and mystical notions, derived from the earliest periods of antiquity, in themselves incorrect, and bearing a very remote relation to the actions of the animal economy. So seducing, however, were the refined speculations of Galen—so powerful was the impression which he produced upon the whole range of medical science, and so little were mankind in the habit of investigating facts, and of drawing legitimate deductions from them, that the humoral hypothesis remained without ever being called in question for many ages, and continued to enjoy a considerable share of its original reputation even to the middle of the last century. The exertions of the chemists and the mechanicians shewed the insufficiency of many of its parts, and for a time diverted the current of opinion into a new channel, yet their own weakness was at length discovered, and the doctrines of the humoralists, although with some modifications, again acquired the ascendency. The pathological system of Boerhaave, which was formed professedly upon eclectic principles, clearly proves the influence which was still attached to the supposed alteration of the properties of the fluids, and as exhibiting the latest and most consistent view of the subject, and one which was brought forward by a man of the first talents and acquirements, it may not be improper to give a brief outline of its most important parts.

Boerhaave regarded the animal system as endowed only with the physical properties of matter, and exhibiting nothing specific in its nature and constitution, except what immediately depends upon its mechanical arrangement, or the operation of its parts upon each other. He professes to commence with the consideration of the most simple diseases; but this simplicity consists not in the nature of the actions which constitute the morbid changes, but in the structure of the parts which are affected. These he supposes to be the minute fibres of which the body is composed, which are made up by the mere mechanical cohesion of its ultimate particles, by the intervention of a cementing gluten. (*Aphor.* 21.) This doctrine, which was probably considered by Boerhaave as a simple exposition of facts, too obvious to be controverted, we now regard as completely hypothetical, and entirely fallacious. It forms, however, the basis of his system; and proceeding upon the supposed existence of this simple fibre, he next assigns to it certain properties of a purely mechanical nature, and imagines what will be their operation in the production of disease. Hence are deduced two great classes of diseases, those of a weak and relaxed fibre, and those of a rigid and elastic fibre; and the causes are pointed out by which these opposite states are induced, and the means by which they may be remedied. From the fibres we come to the vessels and viscera; and regarding these as possessed of mere mechanical properties, and without any consideration of their actions and functions, as forming part of the living system, we have their diseases divided into the classes of relaxation and rigidity, depending respectively upon a defect or excess of the cohesive power of the fibres. Having thus considered the nature of the solids, we next proceed to that of the fluids, which, as being the most easily changed in their qualities, and as being more exposed to the influence of external agents, are generally the more immediate cause of morbid action. In his arrangement of the changes which the fluids experience, he unfortunately proceeds as in the case of the solids; instead of founding it upon actual observation of their properties, he lays down certain abstract principles respecting them, deduced from their supposed inherent physical qualities. As our fluids are formed from the ingesta, and those are all ultimately derived from the products of vegetables, he conceives that they will still retain their original properties. Hence, it is concluded, that under the circumstances to which they are exposed in the body, the fluids will be liable to acquire either an acid, a glutinous, or an alkaline tendency, according to the materials of which they are formed, and the actions to which they are exposed; and from this circumstance we derive the foundation for an arrangement of diseases, in relation to the chemical and physical condition of the fluids. It is scarcely necessary to observe, that these states of the fluids are unfounded; that the existence of an acid or an alkali is merely confined to particular parts—exists in a slight degree only—and never forms an essential character of the constitution; and that the gluten is altogether imaginary.

The next principle which is employed in the classification of diseases, the force of the circulation, or the rapidity of the motion with which the blood passes through the different parts of the body, is derived from a more correct principle, and, to a certain extent, has a real existence; these, however, compose only a small part of the whole, and even their operations are, in some measure, deduced from the preceding incorrect and fallacious data. In all these doctrines, concerning the primary cause and origin of disease, we observe very little reference made to the body, as possessing any powers peculiar to itself, or different from those that belong to inanimate matter; and we may therefore conclude, that any pathological positions that are founded upon them must be entirely erroneous. Considering the extensive information which Boerhaave possessed, and the candour with which he regarded the systems of his predecessors, it is remarkable that he paid so little attention to the opinions that were gaining ground among his contemporaries respecting the specific powers of vitality; so that during the period which elapsed from the first publication of his aphorisms to his death, a period of many years, which was spent by him in the active prosecution of medical science, he introduced very few improvements upon the original work. To this cause, among others, we are to attribute the rapid decline of his system, which, from being almost universally adopted as the basis of pathological reasoning, was in the space of a few years completely abandoned.

We shall be more sensible of the change which was gradually taking place in medical hypothesis, by referring to the works of Gaubius, who was the pupil and successor of Boerhaave, and who adopted many of his opinions respecting the nature and composition of the body. He classed diseases according to the difference in the parts which they affected, rather than from any difference in their operation upon the powers and functions, and consequently divided them, in the first instance, into affections of the solids and of the fluids. He commences by the most simple diseases, and, like his predecessor, he conceives this simplicity to depend upon the nature of the parts which are their seat, rather than upon the nature of their actions. He, however, makes an important addition to the former system, in introducing the living solid among the primary constituents of the body, and in conceiving the vital force as an inherent property of certain parts, in the same manner that elasticity, gravity, attraction, &c. are of other kinds of matter. It must indeed be acknowledged, that his ideas respecting the nature of this vital force are not well defined, either as to the organ by which it is exercised, or the connexion which it bears to the other powers and properties of the body. He had no accurate notions of the difference between muscular contraction and nervous sensibility, as depending respectively upon the specific properties of the muscular fibre and the nervous matter, but he considered the vital force as one undivided power, residing generally in all parts of the body, existing in various degrees, but always of one description. The influence which it possesses over the state of the functions constitutes a frequent cause of disease; but all the irregularities or changes of which it is conceived to be susceptible, are those either of excess or of defect; the first bringing on the state of irritability, the latter that of torpor, and accordingly these form the two classes of diseases which depend upon the affections of the vital force. In determining the causes of these two conditions, the author enumerates many circumstances of a mechanical nature, which we now conceive to be but little connected with the subject, while he overlooks many of those points which we should be disposed to regard as much more essential.

In the remaining part of his arrangement, Gaubius proceeds upon a method, in its general principles, very similar to that of Boerhaave. He divides the solids into containing and instrumental; the first including the vessels and cavities of all kinds, which are adapted to be the recipients of other substances, the latter signifying the instruments or organs by which our functions are immediately exercised. The morbid affections of each of these structures are then enumerated, but this enumeration is founded entirely upon mechanical principles; and however ingeniously, and even correctly, it may appear to be deduced from a theoretical view of the nature of the parts, it will be found to have very little relation to the actual phenomena of disease. After the consideration of the solids, we proceed to the fluids; and their diseases are arranged, as in the former instance, according to the mechanical or chemical properties which are conceived naturally to belong to them, and the necessary deviation from these properties to which they are liable under the circumstances in which they are placed. Of these properties, some are deduced from mechanical, and others from chemical principles; but so little were the former applicable to the subject in question, and so imperfect were the doctrines that were generally received on the latter, that there is perhaps scarcely a single one of all the supposed cases that has any real existence.

The introduction of the vital principle as an agent in the operations of the animal economy, almost necessarily induced a greater attention to the state of the solids, in opposition to that of the fluids. Whatever may be the nature of this principle, or the laws of its action, the mind was impressed with the idea of it being more immediately attached to the solids than to the fluids; and it was difficult to conceive of the existence of any qualities of this kind residing in a body that was not possessed of an organized structure. The writings of Baglivi had, for some time before this period, directed the investigations of physiologists to this part of the animal economy, and had led them to regard the condition of the solids as the first step in the corporeal actions, both in health and in disease. The principles which were developed in his treatise on the moving fibre were original and ingenious; and although some of his fundamental positions are completely erroneous, yet his general conclusions are in many respects just, and they had the effect of shaking the credit of the system which had been uniformly adopted for so many ages.

Baglivi supposes that the regular action and well-being of the human frame depends upon the preservation of the due equilibrium between the solids and the fluids; and he farther supposes that there are two primary sources or origins of motion, the heart, and the membranes of the brain. All the solids are composed of fibres, and these fibres are of two kinds, muscular and membranous; the former of them composing the substance of the muscles, the tendons, and the bones; the latter composing the membranes of all descriptions. As the heart is the centre of the muscular organs, and gives motion to all its parts, so the dura mater is imagined to be that of the membranes; and to this motion or oscillation, as it is styled, are attributed the operations of the nerves, and their powers of action upon the other parts of the body. The fibres differ materially in different individuals, according to age, sex, temperament, habits of life, and various other internal and external circumstances; and are either hard or soft, tense or relaxed, tenacious or brittle, in consequence of the above causes. From these variations in the state of the fibre are deduced the various conditions of the fluids: and he enlarges, with much ingenuity, upon the way in which the blood and the secretions may have their physical and chemical properties affected, by the nature and the degree of the motion impressed upon them by the action of the moving fibres. From these principles he derived the conclusion, a conclusion directly at variance with the hypothesis generally received at that time, that the state of the solids is the most frequent primary cause of disease, and that they affect the fluids much more than these can affect the solids.

Although it appears that Baglivi's doctrines were extensively inculcated, and acquired a great share of publicity, yet the immediate effect which they produced upon pathology was not very considerable, a circumstance which may be attributed, in no small degree, to the erroneous opinions with which they were blended, on many points both of anatomy and of physiology; errors which, it may be presumed, would have been corrected, had the life of the author been prolonged. It is however certain, that the solids from this time became gradually the objects of more attention; while, on the contrary, the doctrines of the humoral pathology were much modified, and received with more reserve, until the complete system of the solidists was perfected by Cullen. This celebrated man lived at a time which was favourable to the development of new doctrines, and he possessed a turn of mind well adapted to the genius of his age. The discoveries that had taken place in the various branches of natural philosophy had tended to destroy that implicit veneration for the wisdom of antiquity, which had for many centuries opposed an insurmountable barrier to all improvement, while both the education and talents of Cullen led him to depend more upon the results of his own observation, and the deductions of his own understanding, than upon the precepts of the schools, which had been handed down from generation to generation, and were adopted rather from authority than from conviction.

The change in pathological opinions, from the hypotheses of the mechanicians and chemists to that of the spiritualists, was accomplished about the same time with the one which we have mentioned above. Although, as was remarked in the former part of this article, some symptoms of this doctrine may be traced in the older writers, and the existence of the *archeus*, or the intelligent superintending principle, was explicitly brought forward by Van Helmont; yet it was scarcely advanced in a systematic manner, or in a matured form, before the time of Stahl. Convinced of the insufficiency of all former hypotheses to account for the operations of the animal economy, Stahl discarded at once all the speculations that were founded upon physical principles, and formed a new doctrine of vitality, in which the actions were all referred to a rational soul, pervading the system, directing its functions, repairing the injuries which it experiences, and resisting the dangers which threaten its destruction. This doctrine was probably derived from the *nature* (φυσις) of Hippocrates, a term which was employed by him and his disciples, in a vague and indeterminate sense, referring partly to the effects that were observed to take place, and partly to the cause producing them, but which seems to have been employed, rather as a method of expressing a series of phenomena, than with any intention of explaining their nature or origin.

The leading doctrine of the Stahlian hypothesis, so far as respects the operation of disease, was, that independently of the physical condition of the body, the soul influences the action of the system, and produces in it certain changes, which have a direct tendency to obviate the injurious effects which might otherwise ensue. The illustration of this hypothesis, and the proofs of it that were advanced, were numerous and striking, but they all proceeded upon the fundamental error of attributing to a certain power, or principle residing in the body, effects which depend upon its original constitution, presenting indeed the most remarkable indications of intelligence in the animal economy, but which cannot be supposed to be produced by any agent which forms an essential part of the system itself. Another great error into which Stahl fell in the original establishment of his hypothesis, an error which has pervaded the writings of all his followers, and even many of the moderns, who adopted his views in a very partial degree only, is, confounding the physical with the final cause of many of the operations of the animal economy. The method which they adopted in their physiological and pathological inquiries, consisted in an attempt to account for all the facts which they observed, not by investigating the circumstances under which they occurred, and in this manner assigning to each of them their proper physical cause, but in attributing them all to the operation of an assumed principle, which at once, in the most summary manner, removed every difficulty, and put a stop to the necessity of any farther inquiry. It had consequently an injurious effect upon the progress of science, both by directing the attention to a fallacious object, and by causing the mind to rest satisfied with the supposed discovery of truth, when in fact no new information had been acquired. This injurious effect was extended to medicine; for as the actions of the body were all supposed to depend upon the operation of a rational principle, that had the power of preventing or correcting all morbid affections, the interference of art could be of little avail, and was as likely to prove hurtful as beneficial.

The Stahlians professed indeed to pursue the plan originally proposed by Hippocrates, of endeavouring, in all instances, to follow the indications of nature, a plan which has been adopted by many of the most judicious of the modern practitioners; but there is a fundamental difference between the two systems. In the one case we observe, as a matter of fact, that the corporeal functions are so arranged, and are adapted in such a manner to each other, from the original construction of the body, that certain actions necessarily tend to the well-being of the whole, and not only preserve the machine in its perfect state, but even have the power of correcting some of its irregularities. The Stahlians proceeded upon a principle, which differed from the above, not merely in degree, but in its very nature. They set out by assuming the existence of a specific power or faculty, essentially different from any other of the physical properties of matter, and indeed conceived to be necessarily of an immaterial nature, which had the office of regulating all the corporeal operations, and unless some extraneous circumstance interfered, it was concluded that this principle was always competent to its office. The practice of medicine consequently was reduced within very narrow limits, and consisted in nothing more than preventing any undue interference, and in permitting the operations of the rational soul to pursue their natural course. In fevers, for example, every stage of the disease was conceived to answer some useful purpose, and although it might be aggravated by an improper condition of the body, or from something unfavourable in the circumstances in which the patient was placed, yet the physician was merely to attempt the removal of this irregularity. He was not to endeavour to put a stop to the disease, as it was concluded to be excited for some important purpose; and as it is always easy in medicine to produce facts in favour of any theory, numerous examples were cited to prove the injurious consequences that resulted from cutting short fevers, or from prematurely curing diseases of all descriptions, and patients were persuaded to endure loathsome and painful complaints, and even to welcome them as the most beneficial dispensations.

By a reference to the writings of the Stahlians, it appears that this inertness in practice, which might be suspected as the natural consequence of their principles, actually existed, for we find that they uniformly opposed all interference, as they termed it, with the efforts of nature; that they discarded the employment of all active remedies, and even sometimes encouraged the progress of certain diseases, from an opinion of their salutary tendency. The use of the Peruvian bark in intermittents was long regarded by this sect as unsafe; they seldom ventured upon copious evacuations, they were afraid of employing the cooling treatment in febrile diseases, and in general can scarcely be said to have introduced a single improvement into the practice of medicine, except what resulted from the omission of various useless, and, in some cases, injurious plans of treatment, which had been employed by their predecessors. In one department of the art, however, the value of their exertions must be allowed to have been considerable; the description of the phenomena of disease. Their leading principle being to permit all affections to run their natural course, and to do nothing more than prevent their irregularities, they would necessarily enjoy the most favourable opportunities of observing the progress of disease, while at the same time their attention was directed almost exclusively to this subject. Some of our most esteemed writers on symptomatology and semeiology will accordingly be found either among the professed Stahlians, or among those who embraced the essential part of their doctrine, for many who were direct opposers of the metaphysical language in which the hypothesis was originally clothed, adopted its general views and principles, so far as to admit of the superior effects of the *vis medicatrix naturæ*, to the most judicious efforts of art, when applied with the intention of opposing or interrupting the progress of this salutary operation.

The fondness for metaphysical and abstruse reasoning, which seems so natural to men of an inquiring turn of mind, probably tended to give the Stahlian doctrine a degree of publicity, to which it was from its inherent merits but little entitled, while this same property had the effect of rendering it less easy to detect its fallacy. It accordingly excited great attention, and met with many supporters, and although there are no persons at the present time who embrace it in its full extent, or under the form in which it was originally proposed, yet a very numerous sect may be considered as having sprung from it; and its influence upon medical hypothesis may be traced even in the writings of our contemporaries.

We have already remarked that there is a connexion between the spiritualists and the vitalists, so that it is difficult to decide into which of these classes certain individuals ought to be placed. The methods upon which they profess to proceed are indeed essentially different, in as much as the former begins by assuming an hypothetical principle, for the purpose of explaining the phenomena, whereas the latter attempts to explain these phenomena solely by these faculties or powers which essentially belong to the living body. But we may easily conceive that these opposite systems may lead to similar conclusions, and that the same principle which is assumed by one writer as conveniently explaining the phenomena, may by another be supposed to have an actual existence. In this kind of intermediate state, as forming a link between the two classes, may be placed Brown and Darwin.

Both the personal character of Brown, and the spirit of his writings, render it probable that he was not a nice observer of facts, and that his system is to be regarded rather as the offspring of a powerful mind, that had seized upon a few leading points, and had pushed them far beyond the limits of correct induction, than as the matured result of patient research, founded upon a cautious generalization of well ascertained phenomena. The simplicity of the doctrine would be a strong argument in its favour, could the basis on which it stands be fully established, but upon examining its foundation we are led to observe, that much of this alleged merit consists in the employment of a few terms, not very definite in their acceptation, and which are convertible to a variety of purposes.

The most important of Brown's general principles may be comprised in the following propositions. As inanimate matter exhibits certain powers on which its actions depend, so living beings possess a specific principle or power, from which their appropriate functions originate; to this the name of excitability is applied. Different individuals possess different degrees of excitability, or at least are more or less affected by those causes which act upon this quality. Every circumstance, either internal or external, which in any way affects the living animal, is called a stimulus, and contributes to expend a portion of the excitability. Upon the proper action of these stimuli depends the due development of the vital powers; if they be applied in too great a degree, the excitability is too speedily expended, the animal becomes exhausted, and falls into a state of *indirect debility*. If, on the contrary, there be a deficiency of stimulus, the powers of life fail from the want of being called into action, a state of *direct debility* ensues, and the excitability becomes preternaturally accumulated. The two kinds of debility, although considerably similar in their effects, are, as it appears, totally opposite in their causes: when the body suffers from the want of food, it falls into a state of direct debility, but if the system has been unusually excited by a large quantity of wine, and a state of languor follows from this cause, the condition thus induced is a state of indirect debility; the first, therefore, is from defect, the latter from excess, of excitement. The state of the body with respect to sensibility is always the same in kind, and capable of no difference except in degree, so that there is no variation in the state of the same individual, except what depends upon the greater or less quantity of excitability which is called forth at different periods. According to the hypothesis, as it was originally delivered by Brown, the portion of excitability possessed by each individual was allotted to him at his birth, nor could the original stock by any means be increased. From some cause, however, which is not well explained, it cannot be expended at more than a given rate, without producing a morbid condition of the body, and if from any cause this rate be exceeded, a certain portion of time is requisite to restore the balance between the supply and the deficiency. Another of the original tenets was, that the excitability resides both in the muscles and in the nerves, and that its quantity in the different parts of the body exists always in the same proportion with relation to each other, so that if by any cause it becomes excessive or defective in any organ, it likewise becomes excessive or defective in every other part, according to the natural balance which exists between them.

Among the most important pathological doctrines of Brown, is the position that all diseases depend simply upon the excess or defect of excitability, and may all therefore be divided into two classes, to which he applied the name of sthenic and asthenic, and that the principal generic difference of the diseases of each class consists in the parts which they affect, modified by peculiarities of temperament, sex, age, habits of life, &c. The action of remedies is to be directed solely for the removal of one or other of these states of debility; they never operate in any specific manner, and they differ only in the greater or less degree of their effects. A most important and much controverted principle was respecting the existence of any thing which could be called a direct sedative, the possibility of which was absolutely denied by the Brunonians. The substances which are commonly classed under this denomination, they conceive to be either feeble stimulants, apparently producing sedative effects, but this only with relation to the greater activity of other substances, or stimulants, which possess the power of very rapidly inducing the state of exhaustion, so that the period of stimulation is overlooked, or is confounded with their secondary effect, that of indirect debility. We may remark, that the excitability of Brown is supposed to be attached both to the muscles and to the nerves, or that the power of motion in the one, and of sensation in the other, belong to the same principle, and that this principle is so diffused over all parts of the system, that the two faculties keep pace with each other, and in the same individual are always augmented or diminished in the same ratio.

The principles that are maintained by Darwin in his Zoonomia, are fundamentally the same with those of Brown; but, in consequence of the different character and disposition of the author, and the different circumstances in which he was placed, they have assumed a very dissimilar aspect. Darwin, like Brown, sets out with the assumption of a certain power or faculty, which is attached to the living body, and is the immediate cause of the phenomena of life, to which he gives the name of spirit of animation or sensorial power. It is supposed to reside both in the muscles and in the nerves, and to be equally the origin of motion and sensation. It is called forth, like Brown's excitability, by the action of various stimulating powers, and is capable of accumulation and exhaustion, while upon its states of excess or defect, depend all the morbid affections to which the body is liable. The system of Darwin does not admit of the possibility of direct sedatives; it assumes the existence of the two kinds of debility, the one arising from the defect of stimuli, the other from their excessive action, corresponding exactly to the direct and indirect debility of Brown. In two important points, however, the system of Darwin possesses an obvious advantage over that of its rival. It does not assign to each individual a limited portion of excitability, which is allotted to him at birth, and which is afterwards incapable of receiving any addition, but the sensorial power is conceived to be generated by the nervous system from time to time, as it is required for the purpose of life, by a process analogous to secretion. Darwin also admits the possibility of a partial excess or defect of this power, and even supposes that it may exist in excess in one organ, while it is deficient in another; a supposition which forms the basis of some of his most ingenious and plausible pathological speculations.

But although, in their foundation and general outline, the hypotheses so nearly coincide, they differ most remarkably in the character which they assume, as exhibited in the works of their respective authors. Darwin, to a mind capable of embracing extensive views of science, united a fondness for minute detail; he devoted the greatest part of a long life to the actual examination of the phenomena of disease, and had his memory well stored with individual cases, which were, on all occasions, ready to be produced in support of his principles. The system of Brown, which owed its celebrity, in a great measure, to its simplicity, and to the facility with which a few leading doctrines appeared to be applicable to all the purposes of practice, became, in the hands of Darwin, completely transformed, and was as remarkable for its minute shades of distinction, and for its complicated arrangement, as its prototype had been for the opposite qualities. In the Zoonomia, diseases are divided into four great classes, depending upon certain functions of the sensorial power; these are, irritation, sensation, volition, and association. Definitions are given of these terms; and all the morbid affections of the body are referred to one or other of these four heads, with much apparent accuracy, and professedly upon the sole grounds of experience and observation. The concurring testimony of the public voice seems, however, to have decided, that in his great work Darwin has completely failed; that he has rendered the system more intricate and abstruse, without really making it more practically useful; that his classification is founded rather upon metaphysical than upon physical principles; that his generic divisions are fanciful, and his pathological deductions, although often apparently ingenious, seldom the legitimate result of well-established theory, but are to be regarded rather as a tissue of unconnected opinions, than as the well-arranged members of a regularly organized system.

We now come to those writers, to whom the designation of vitalists more strictly applies; a sect which may be characterised as professing to deduce all their opinions from the correct observation of the essential powers and faculties of the living body, without the assumption of any hypothetical principles, or the introduction of any agents for the sole purpose of explaining phenomena. In tracing the progress of opinions, it must have been perpetually observed, that there is the greatest difficulty in ascribing to each author his exact share in the formation of any particular hypothesis; some traces of almost all our present doctrines may be found in the oldest writers, while, on the contrary, certain inconsistencies may be pointed out in the writings even of the most correct and judicious of the moderns. In the present case, however, we think the merit of viewing the animal economy, in what we regard as the most philosophical light, is due to Hoffmann. Hoffmann, like Stahl, felt the insufficiency of all preceding opinions, and clearly perceived that the animal body was governed by laws essentially different from those which influence inanimate matter; but, in order to supply this deficiency, he had not recourse to any imaginary agent like the *archeus*, or the *anima* of his contemporaries, or the excitability of later writers, but by carefully observing the nature of the operations of the respective parts of the body, he perceived that certain organs possessed specific actions, and that of these the brain and the nerves were the most remarkable, and the most unlike what was to be seen in other natural objects. To the appropriate powers of the nervous system, therefore, he referred the effects of vitality, and more particularly to the manner in which the nerves are connected with the organs that are immediately subservient to motion. The precise mode in which the nerves act in this process is not explained; but the general result is the production of two morbid states of the system, dissimilar, or even opposite to each other, to which the appellations of spasm and atony were applied; the first expressing the condition of increased, the second of diminished activity. Hoffmann was a copious, and rather inaccurate writer, and his productions generally want that precision which is more especially desirable in the proposing of a new hypothesis; but there is a sufficient reason for concluding that he distinctly saw the grounds of his theory, and was fully aware of the essential difference between his opinions and those of his contemporaries. Their merit, however, would probably have remained disregarded, or without making any extensive impression upon the general state of medical science, had they not been embraced by Cullen, materially improved by his judicious modifications, and, in consequence of his talents and situation, presented in a very interesting form, and brought into very general notice.

Cullen fully acknowledges his obligation to Hoffmann, and confesses that he had borrowed from him the essential points of his doctrine; but it is universally allowed, that the alterations which he introduced into it were all of them improvements, rendering it more comprehensive, and more consistent in its different parts. He discarded, even more fully than his predecessors had done, the action of the merely mechanical powers of matter, as accounting for the phenomena of vitality, and rests all his hypotheses solely upon the specific properties of the living body. The great agents in all the operations, either of health or of disease, are supposed to be the minute fibres of the nerves and muscles, which he conceives to be the immediate cause, not only of sensation and of motion, but of all the imperceptible changes which are gradually effected in the internal economy of the system. A great part of the most important of these changes are produced through the medium of the capillary extremities of the arteries, and this action of the vessels, as it is termed, was substituted for the physical and metaphysical speculations of his predecessors, and was supposed competent to produce all the changes that occur, both in the state of the fluids and of the solids. He adopted the spasm and atony of Hoffmann, and refined so far upon their nature, as to conceive it possible for the two conditions to exist at the same time, in different parts of the system.

Cullen did not possess a sufficiently clear and decided idea of the difference between the properties of the nerves and the muscles, producing sensation on the one and motion in the other, which were afterwards characterized by Haller, under the names of sensibility and irritability, and he was led into some pathological errors in consequence of his imperfect knowledge of animal chemistry. Besides the additions which he made to the stock of actual information, he was of the greatest service to medicine, by introducing into it a spirit of philosophical research, and by discarding from it a great proportion of that mass of useless and antiquated learning which had been accumulating for ages, and with which it had been so much encumbered. There are few of Cullen's hypotheses which have not experienced some modifications, in consequence of the rapid progress of science, since the time when he first commenced his career; yet they may be considered as still forming the basis of the opinions which are adopted by the most enlightened physicians of the present day. His theory of fever was finished with peculiar care, and must be allowed to be preferable to any which had preceded it, but it is obscured by the introduction of the *vis medicatrix*, a power which, after all the attempts that have been made to explain it upon correct principles of reasoning, savours too much of the metaphysical pathology, with which the works of Cullen are, for the most part, uncontaminated. The doctrine of excitement and collapse is not without its weak parts, but it is, perhaps, upon the whole, more consistent with the phenomena of disease than the sthenic and asthenic states of Brown, which were obviously borrowed from it, while his view of the gradual development of the system, its progress to maturity, and the changes which it undergoes upon the approach of age, must ever remain a beautiful specimen of inductive reasoning, applied to the operations of the animal economy.

But Cullen has derived his principal celebrity from the power which he exhibited in controverting the opinions of others; for while his professed adherents, who attached themselves to his system in all its parts were not numerous, there are few writers, in any age, who have been more successful in overthrowing the doctrines of their predecessors. When he entered upon his career, the theory of Boerhaave was almost universally adopted; for although Hoffmann had already published his new system, it had excited little attention, so that the chemical state of the fluids, together with their acrimony and lentor, and other imaginary conditions of their physical properties, were regarded as the general causes of disease. All this visionary fabric was completely destroyed by his genius, so that, from the time of Hippocrates to the present day, we have no example of a more sudden and complete revolution of opinion than that which was effected by Cullen, and those of his contemporaries or immediate successors, who had derived their ideas from his lectures and publications.

We have already given an account of the systems of Brown and Darwin, which, although posterior to Cullen, were not superior to it in the correctness of the deductions, and were less applicable to practice. The former of these, from causes which we have already endeavoured to explain, acquired for some years a prodigious degree of reputation in this country, and had many very zealous disciples in Italy and Germany. Among the latest systems of pathology, which have had any material influence either on the opinions or practice of medical men, we may rank the chemical hypothesis, and that which conceives the cause of all diseases to originate from a deranged action of the circulation, producing a state of general or partial plethora.

The chemical hypothesis was the immediate result of the remarkable discoveries that were made about 40 years ago, on the nature of the various gases, and especially on the application of them, by Black and Priestley, to explain the functions of respiration. The hypothesis that was formed by Crawford, to account for the production of animal heat upon chemical principles, seemed still farther to countenance the system; and the attempt that was made to imitate the effects of digestion by Spallanzani, and the various processes that were established by different chemists, to form the secretions out of the body by the action of chemical reagents, although confessedly very imperfect, still tended to produce the same general sentiment. It was therefore assumed by some physiologists, that all the changes which are continually going forwards in the system are strictly chemical changes; that the substances of which the body is formed still retain their original chemical properties, after they enter into the composition of the solids and the fluids; and that the principal use or object of the vital functions is, to bring the constituents of the body within the sphere of their mutual action, and to enable them to make the proper exchange of their elements. From physiology this hypothesis was gradually extended to pathology; it was maintained, not only that the natural, but even that the morbid changes in the system consisted of a series of chemical compositions and decompositions, that medicines operate by their chemical action on the constituents of the body, either by affording them some element of which they were deficient, or by enabling them to exercise some chemical affinity, or to produce some chemical decomposition, which might restore them to their healthy condition.

Among the earliest applications of chemical reasoning to pathology, at least in this country, was the attempt to explain the beneficial effects of the citric acid in scurvy, on the principle that the disease depended upon a deficiency of oxygen, and that the acid afforded this element to the system. But the most elaborate hypothesis of this kind was that which attributed phthisis pulmonalis to an hyper-oxidated condition of the system at large, and particularly of the blood, which, in passing through the lungs, brought upon them a certain species of inflammation, which produced tubercles and the other phenomena of the disease. To remove this superabundance of oxygen, remedies were applied, both through the medium of the circulation, and directly to the lungs, which were supposed to have the effect of de-oxidating the blood; and according to the usual custom on such occasions, the most flattering success attended the trials that were made of the new remedies. Although the chemical pathology may be considered as having originated in this country, it was speedily adopted by the Germans, and was carried by them to a much greater extent than it ever obtained in its native soil. For some years, it maintained its ground among some of the most learned professors of that country, and even divided the empire of public opinion with the favourite and alluring doctrines of Brown. Nor is its influence yet entirely superseded; for although we conceive that there is not a single individual in this country who attaches importance to the chemical pathology, at least as a general system, it would seem that it has still some learned and powerful adherents on the continent.

It will not be necessary for us to enter into a very minute detail, either of the principles of this hypothesis, or of the arguments by which it is supported. The general fact upon which it rests is indeed true, that the vital actions do not supersede the laws of chemical affinity; but the operation of this principle will be found extremely inadequate to accomplish all the effects which characterize the animal economy. The two appropriate powers of life, contractility and sensibility, have no relation to chemical affinity, and the operation of this principle is only so far concerned in the constitution of the body, or in the performance of any of its functions, as it assists in affording the proper medium or instrument through which its appropriate powers may operate. Thus, we admit, that a certain combination of chemical elements is necessary for the composition of the muscular fibre, or for the nervous matter, but we are not authorized in concluding, that the contractile or sensible powers of the muscle and nerve will continue in a perfect condition as long as their chemical nature remains unchanged. But, if we have no evidence of the vital powers in their healthy state being the necessary result of chemical affinity, still less have we any proof that the morbid changes which constitute disease are necessarily related to any changes in the chemical constitution of the body. With respect to the facts which have been adduced in favour of the chemical doctrine, however favourable to it they might at one time have appeared, it is now generally allowed that they are of the most ambiguous description; that many of them are entirely without foundation; and that those which appear to be better established may be much more correctly explained upon other principles. Indeed, the more we examine into the supposed virtues of what may be styled chemical remedies, the less reason do we find for placing any dependence upon them; so that, except some that appear to act immediately upon the contents of the stomach and bowels, and perhaps also upon the urinary passages, we have no decisive evidence of the existence of any substances to which this appellation can be correctly applied.

The last pathological hypothesis which we shall notice, that which attributes all the derangements of the animal economy to general or partial plethora, seems rather to have gradually risen up from the supposed result of practical experience, than from any theoretical views of the nature of the animal economy. The great extent to which the system of depletion has been carried, in the first instance, by the practitioners of America and the West Indies, and more lately by those in different parts of Europe, has given a powerful bias to medical opinions on all topics, and, indeed, seems to reduce the whole of the practice of medicine to little more than a succession of evacuations, or an alteration in the different methods of abstracting the fluids from the system. That a beneficial effect has been produced by this means, both in theory and practice, we are fully disposed to admit; but it would be contrary to the uniform experience of ages, were we not induced, by so great a revolution, to place somewhat too high a value upon our present opinions, and to make us embrace, with too much ardour, the doctrines which we regard as being derived from a greater variety of facts and analogies than any others which had preceded it.

The hypothesis of plethora, or the irregular distribution of the blood, which appears to have had so much influence upon the minds of practitioners, has lately assumed a more connected and methodized form, in Dr. Parry's Elements of Pathology; and we shall accordingly give a concise view of some of the most important doctrines which it contains. The author begins by observing, that the sanguiferous system is the one which is the most frequently deranged, or that from which almost all diseases originate; and partly in consequence of the natural constitution of the body, and partly from the acquired habits of civilized society, he supposes that these derangements very generally proceed, in the first instance, from an excess in the quantity, or the momentum of the blood. But besides an excessive quantity of blood, considered with regard to the system at large, the blood-vessels are peculiarly liable to local plethora, a state of parts which may occur even where there is a general deficiency in the quantity of the fluids. This plethora may arise from two distinct causes, either from the increased impetus of the heart, or from the resistance of the vessels; but although the mechanical effect of these causes be nearly the same, and the mode of treatment be also, in a great measure, similar, yet the state of the vital powers of the system, or at least of the part affected, are totally opposite to each other.

However widely the ultimate conclusions may differ at which we arrive, still, as long as we are influenced by the observation of the same phenomena, there must be a kind of general correspondence between our ideas, although clothed in very different language. Thus the diseases of constriction and relaxation among the ancients, the putrid and inflammatory diseases of Boerhaave and Cullen, the sthenic and asthenic states of Brown, and the excess and defect of sensorial power, so much insisted upon by Darwin, may be regarded as the prototypes of Dr. Parry's two forms of plethora. According to this system, all diseased action, at least with a very few exceptions, may be considered as having the same origin, depending upon an excessive momentum of the blood; while the varieties which we observe depend, first, upon the degree in which it exists, as being either general or local; and, secondly, supposing it to be local, upon the structure or functions of the organ which is primarily affected. The local affections are determined by various circumstances, including those causes which arise from some affection of the natural powers of the system, or from the operation of extraneous causes. It is upon the general doctrine of the excessive excitement of the sanguiferous system, and of the tendency to plethora, which may in different ways be determined to individual parts, that Dr. Parry accounts for the conversion of diseases into each other, and for the relief of one affection by the invasion of another, which does not appear to have any very immediate connexion with, or dependence upon the former. Besides ascribing very nearly all morbid affections to excessive momentum, or to plethora, another leading feature of Dr. Parry's pathology is, that the affections of the nervous system are entirely secondary or subservient to those of the sanguiferous; and that, in conformity to the general system, these likewise originate from an excessive determination of the blood to the substance of the nerves. We arrive, therefore, at the conclusion, that all diseases have one common origin, and that this is the excessive momentum of the blood, either manifesting itself by a direct affection of the sanguiferous system, general or local, or by an indirect affection of the nervous system, likewise depending upon an increased determination of blood to the part. The distinction between diseases arises, therefore, principally from the parts that are affected; and the character of their symptoms is determined, either by the specific structure of the organ, by the nature of the cause producing the disease, or by the peculiar habits or constitution of the individual.

We are disposed to attribute considerable importance to Dr. Parry's system of diseased action, both as it appears to be deduced from more correct principles of reasoning than many that have preceded it, and because it coincides remarkably with many of our best established opinions on the treatment of disease. Yet, as is invariably the case, we think that he has carried a valuable and useful principle to an extravagant length. We may admit, that the sanguiferous system is more frequently affected than the nervous; but, from a view both of the causes and effects, we conceive that there can be no doubt that the nervous system is not unfrequently the origin of disease, as well as the part which is more immediately affected. We may farther admit, with Dr. Parry, that the habits of civilized life tend to produce plethora; but, at the same time, it seems equally certain, that the same state of society produces the directly contrary condition, that in which the whole body is relaxed and feeble, and where, as a matter of fact, depletions or evacuations of all kinds can be employed only in moderate quantities, or are even injurious. With respect to the grand principle, that all diseases originate in plethora, or excessive momentum of the blood, even should we allow it to be true as a literal fact, still the circumstances under which it exists are so totally opposite to each other, as to form no ground for considering them in the light of similar, or even analogous operations. The mere circumstance of a great quantity of blood being collected in a part, is to be regarded as an accidental effect, which may arise from totally opposite causes, and in the production of which there is perhaps not a single step in the process common to the two cases. Upon the whole, we consider Dr. Parry's pathology as the production of a man of talents and originality, and as exhibiting a bold outline of the diseased actions of the animal economy, but in which many minor, yet essential parts, are omitted or overlooked, in consequence of too daring an attempt at generalization.

Part III. THERAPEUTICS.

After having considered the general doctrines of disease, the nature of the causes which produce the morbid affection of the body, and the effects which follow from these causes, we next proceed to the third branch into which we proposed to divide our subject—that of Therapeutics, or an account of the operation of remedies, as employed either to obviate or remove disease. Under the head of Therapeutics is frequently included Materia Medica, or an account of the agents used in medicine; and Hygeine, or the management of all those circumstances that concern the health.* With respect to therapeutics, properly so called, or the general principles which are concerned in the operation of remedies, it is obvious that they must depend very much upon the particular views which we adopt on pathology. Whatever hypothesis we may form of the nature of disease, we must embrace similar notions with respect to the means that are to be employed for their removal, the one being necessarily the counterpart of the other. If we conceive that the origin of disease is in the fluids, our object must be to correct or change the state of the blood and the secretions; if, on the contrary, we attribute them to the nervous system, we should employ the remedies that act upon the brain and nerves. According to this idea, it would follow, that at present we have no general principle of therapeutics, on which we can proceed as applicable to all diseases; for we have already shown, in our account of the prevailing sects and opinions in pathology, that we are in possession of no hypothesis of the nature of disease, against which powerful objections may not be urged. Although certain individual points of theory may be received with some confidence, yet we are unable to unite them together into one whole, or even, in many cases, to find an intermediate link by which they can be connected together.

But although it thus seems difficult, or even impossible to lay down any general principles, certain objects may be pointed out as particularly belonging to therapeutics, which are often within our reach. The most important of these are the three following: first, to remove the causes of disease; secondly, to remove the disease itself; and, thirdly, to remove its effects. It is evident, that the treatment of these objects is not necessarily connected with a perfect theory, but that they may, in a greater or less degree, be accomplished by observation and experience, provided our observation be sufficiently accurate, and our experience sufficiently extensive. The removal of the cause of disease differs so essentially from the removal of the disease itself, and often depends upon means of so totally different a nature, that this part of Therapeutics has obtained the distinct appellation of Prophylactics. We do not, however, propose to treat of it under a separate head, but shall, in each case, notice those circumstances which are esteemed the most effectual in preventing the accession of any particular disease.

In order to accomplish the objects mentioned above, certain means or instruments are necessary, some of which operate upon the extraneous circumstances which produce disease, others upon the body itself, either changing its nature, so as to render it unsusceptible of the action of the extraneous circumstances, or, if the action has taken place, counteracting or removing its effects. These means, or instruments, have obtained the general name of remedies, meaning in general all those things which prevent or remove disease, although the use of the term is frequently restricted to designate those agents alone, which are immediately applied to the body, or received into it, for the purpose of relieving some particular morbid affection. In this more limited sense, they are usually styled medicines. As we acquire the knowledge of the use of remedies from the experience of their effects, so it becomes the great business of the practitioner to learn in what state of the body certain effects are to be expected from certain remedies.

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* The first of these topics has been already treated of in a separate article, to which we must refer our readers

The circumstances which guide our judgment on these occasions, or which *point out* these states of the constitution, are technically called indications, and the practice of medicine is consequently reduced to two main objects, to discover what are the proper indications, and how these indications are to be fulfilled. In laying down the indications of cure, we are to attend to every circumstance respecting the patient, which may be connected in any way with his constitution, and his general habits or modes of life; to every thing which can throw any light upon the past, present, or even future symptoms of the disease; and to any peculiarities which he may possess with regard to the operation of remedies. It appears, therefore, that in the formation of our indications, or in laying down our plan for cure, two distinct sets of objects are to be kept in view: first, all those points which refer immediately to the individual; and secondly, those which refer to the general nature of the disease. There are instances without number, which demonstrate the necessity of ascertaining, not merely what is the disease which we are called upon to treat, what name we ought to apply to it, or what place it should occupy in a nosological system; but still farther, how it is modified in the individual case, or what phenomena it presents, which may afford us the specific indications, as applicable to that particular patient. So powerful is the operation of these circumstances, that the treatment of each case of the same disease, produced perhaps by the same specific contagion, or by any other cause of an equally limited operation, may require exactly an opposite system of remedies, or that what is most salutary in one case, may be as certainly noxious in the other.

The modifying circumstances may be divided into two classes, those which are necessarily connected with the individual, and those which are extraneous to him. Among the most important of the first class, are temperament, age, sex, confirmed habits, previous diseases, and various idiosyncrasies; among the second class may be placed what have been called the non-naturals, also trades or occupations, and various modes of life. All these points ought to be ascertained before we can proceed with any certainty in the cure of the disease; and not unfrequently they so affect its symptoms, that a previous investigation of them is absolutely essential to the knowledge of the disease itself. In the course of our remarks on pathology, we had occasion to point out the effect which all these circumstances had in the production of disease; and it is easy to suppose, that a corresponding effect will be experienced in the operation of the means which we employ to remove it. It would, however, carry us far beyond our prescribed limits, were we to enter individually upon each of these topics, and to develope their action in succession. We shall, therefore content ourselves with noticing them under the respective diseases to which they more particularly belong, as they pass under our review in a subsequent part of the article.

Before we enter upon the consideration of the remedies for disease, we must make a few preliminary observations. In tracing the history of medicine, we have had occasion to refer to an opinion, which has had many adherents, and has obtained the scantion of many great names, that the animal system is so formed, and has its powers and functions so adapted to each other, that, in the common course of events, every disease has its remedy naturally implanted in the constitution. Whenever any morbid condition takes place, its existence necessarily calls forth some other condition, or produces some change which counteracts the former. On the contrary, it has been urged by others, that the morbid changes which occur in the system are esentially injurious to it; that they are to be decidedly opposed by our remedies; and that the great object of the physician is to produce a change in the body inconsistent with the state which constitutes the disease. As a general position, this latter opinion is the one which we are inclined to adopt, although, at the same time, it must be admitted, that the animal frame, like every other material object, exhibits a degree of contrivance, and of adaptation of its different parts to each other, by which certain morbid actions necessarily tend to their own destruction; and, if not excessive in their operations, will effect a cure without the interference of art. The proper plan for the practitioner, however, is not to permit either of these theories to acquire exclusive possession of his mind, but, by a course of observation, to make himself acquainted with the actual powers of the system, and with the precise degree in which they manifest, or appear to manifest, this self-preserving property. In this way of proceeding, the physician acts upon the same principles which influence our operations in directing the physical powers of nature in the various arts of life. The agriculturist and the mechanic know that the exercise of their respective professions requires a previous knowledge of the properties of nature, which must form the basis of their proceedings; that they must take advantage of those actions which promote the objects they have in view, and endeavour to counteract those which would oppose them. Some of the doctrines of the great father of medicine lead to what has been styled the *expecting* treatment. It was directly insisted upon by Stahl, and, indeed, forms one of the distinguishing features of his practice; but, with the decline of his hypothesis, it has been gradually abandoned, and although the spirit of the age may in some degree lead to an inactive or temporising system, yet it arises more from a species of medical scepticism, than from any theoretical views which have been entertained on the subject.

It has been often a matter of dicussion, whether, in forming our indications of cure, we are to direct our attention to the removal of particular symptoms, or are to endeavour to find out the cause of the symptom, and make these causes the object of our attention? In favour of the first mode, it has been argued, that all which we really know of diseases consists in the knowledge of their symptoms, and that when we attempt to go beyond this, and conceive ourselves able to understand the more intricate operations of the animal economy, we are liable to fall into the grossest errors. On the other hand, it has been replied, that the same symptoms may originate from opposite states of the system, and depend upon a condition of the functions precisely the reverse of each other; and that even where this is not the case, and were we able in each particular instance to observe some diagnostic mark which might enable us to discriminate between circumstances that, to common observation, appear similar, still the removal of the symptoms is by no means adequate to the removal of the disease. In some cases it may even be adverse to it, because the symptoms may be the natural process for carrying off the disease itself, which should rather therefore be promoted than counteracted. The same kind of answer may be given to this question which has been already made to some of an analogous nature. It is a matter of experience, in which we are to form our judgment on each individual case, rather than apply to all of them any one general principle. There is considerable weight in the observations of both parties; and great evils have arisen from the opinions of either of them having been carried to an undue excess. The older systematics, especially the chemists, who proceeded upon a false pathology, in their attempts to remove the fundamental causes of disease, frequently, no doubt, fell into egregious and mischievous errors; while, on the other hand, it is equally certain, that the practice of many of the moderns, who, pretending to disregard theory, have professed a kind of refined empiricism, has been at least as useless from its inertness, as the other was from its ill-directed energy. Upon the whole, we may conclude, that the best plan of proceeding is to form our indications from the union of theory and experience, when we are sufficiently cautious in our reasonings with respect to the one, and sufficiently accurate with respect to our deductions in the other. A judicious investigation into the probable condition of the system which acts as the immediate, or, as it is technically called, the proximate cause of the disease, together with an intimate acquaintance with morbid phenomena, and an extensive knowledge of the history of such cases as most nearly resemble that under consideration, must obviously give us the best ground for forming our plan of cure, and will afford us the safest guide in the subsequent management of the patient.

The correct method of proceeding in our arrangement of therapeutics is, *first*, To ascertain the objects which we wish to accomplish in the cure of disease; and, *secondly*, To enquire what are the means by which these objects are to be accomplished. Our knowledge of the animal economy is, however, in too imperfect a state to enable us to make any considerable progress in the first of these objects; and yet, without some attempt at a rational method, our endeavours to acquire a just conception of the latter must be entirely fruitless. The utmost point to which we can safely proceed, in the present state of science, is, to form an idea of those functions which are immediately necessary for the continuance of life, and then to consider what are the general causes by which they are liable to be deranged. Of these functions, the most essential in all respects is the circulation of the blood, as affected by the heart and arteries: next to this comes the nervous system: and in the third place, we have the nutritive system, which, in addition to the heart and nerves, requires the action of the absorbents and secretory glands. For the performance of these functions the body is possessed of two powers or faculties peculiar to itself, contractility and sensibility; and it is also influenced, to a certain extent, by the powers which operate upon unorganized matter. Two principles of arrangement thus present themselves. We may proceed either according to the general nature and properties of the constituents of the animal frame, considered as one whole, or according to the separate functions of the body, and the organs by which they are respectively exercised. To a certain degree we may obtain the benefit of both these modes of arrangement, by attempting to unite them into one system; which, if it could be accomplished, would afford us a perfect classification.

In pursuance of this plan, we must take into consideration the causes which increase, and those which diminish, the powers of contractility and those of sensibility generally, and afterwards each of them respectively. We may then examine, in what degree each of the three systems mentioned above are affected by the faculties of contractility and sensibility, and in what way we have it in our power to increase or diminish each of them with respect to these systems. For example, beginning with the circulation, we must inquire, in what degree it is connected with the faculty of contractility, and how far we possess any means for augmenting or diminishing the contractility, with reference to the heart and arteries. We must then proceed, in the same manner, with respect to the sensibility; and, afterwards, we may consider, whether these two faculties, as far as relates to the action of the heart and arteries, have any affections except those of excess and defect. We may conclude this division of the subject by investigating the connexion which subsists between the circulating system and any of the physical powers of matter: *first*, Those of a purely mechanical nature; and, *secondly*, Those which may be referred to chemical affinity. A similar kind of process may then be gone through with respect to the nutritive system; in which the absorbing and circulating organs are to be regarded as the more essential or specific agents, and afterwards with respect to the brain and nerves.

Were our knowledge of the animal economy complete, this, which may be called the natural arrangement of the objects of therapeutics, would embrace every thing we should wish to accomplish; but, in the present state of the science, we are obliged to have recourse to a more empirical plan, and to derive our method from the more obvious effect of remedies, paying comparatively little attention to the intimate nature of their operation. But although we may make this kind of empiricism the basis of our proceeding, it will be difficult, if not impossible, altogether to avoid the influence of theory; and we accordingly find, that the writers on therapeutics, and the materia medica, although professing to arrange their remedies from their obvious qualities and effects, have, in fact, deviated very widely from this track. We have, for instance, a long list of demulcents, the object of which is to sweeten the blood, and remove the acrimony of the fluids; we have incrassants to thicken them, and attenuants to lessen their viscidity or lentor. We have medicines for accelerating the motion of the animal spirits, and others for retarding it; and a variety of objects are assigned to the articles of the materia medica, some of which, we may be confident, have only an ideal existence, and others are totally beyond our power to accomplish.

In our account of the materia medica we divided remedies into two classes, general and particular; the first operating on all parts of the system, and on the functions generally; the latter on some particular organ, or upon some one function, or system of functions, only. The latter class of remedies, which constitute the immediate object of pharmacology, we considered under the article MATERIA MEDICA; the former, or the general remedies, belong more especially to the subject of therapeutics. These may be arranged under the ten following heads: 1. Diet; 2. Air; 3. Temperature; 4. Soil and Situation; 5. Exercise; 6. Occupations, and Modes of Life; 7. Habits; 8. Clothing; 9. Sleep; 10. Passions. Upon each of these topics we shall now offer a few observations.

As that which has the most direct and immediate effect upon the state of the general health, and especially as what we have it the most in our own power to control and regulate, we shall commence with the consideration of diet.

The regulation and management of the diet has been made the subject of many volumes, and has even been regarded as a distinct branch of medical science, under the denomination of DIETETICS. In this place, however, we must consider it only in a general point of view, or at least without going into any very minute detail. We shall divide what we have to say concerning it into two parts. We shall first consider the general principles on which we found our doctrine and practice respecting the nutritive properties of various articles; and we shall, in the second place, arrange all the articles which are employed in diet in their respective classes, either according to their physical properties, or their relation to the different departments of natural history.

SECT. I. *General Principles of Dietetics.*

The medical practitioner may regard the management of the diet in various points of view; as to the nature of the articles employed; as to the quantity used; as to the particular kinds of diet applicable to different diseases; and, independent of disease, we may also inquire into the kind of diet which is most suitable for different ages and constitutions. In considering the nature of the articles employed in diet, the first great division is into solids and fluids: solids may be divided into animal and vegetable substances—animal substances, as they are taken from quadrupeds, birds, or fish; vegetables, as they consist either of the seeds, fruits, roots, or leaves, of the respective plants. Fluids may be arranged under the heads of aqueous infusions, fermented liquors, or distilled spirits. Besides these, which may be considered as including the principal classes of substances employed in diet, we have some of an intermediate nature, as milk, which partakes of the properties both of solids and of fluids; we are also to consider the action of the different processes of cookery in changing or modifying the consistence of the articles subjected to them; and there are a variety of bodies employed in diet, which are not in themselves capable of nutrition, but which are agreeable to the palate, and supposed to promote the action of the digestive powers, or possess some accidental, or perhaps even imaginary properties, which have contributed to bring them into estimation. Of this latter description, we may mention the following; tea and coffee, which, when in a state of infusion, are so frequently used in our diet, sugar, salt, acids, spices, and various other articles.

One of the most important functions of the animal body is that which is exercised by the stomach and contiguous part of the alimentary canal, by which aliment received into the organs undergoes a certain change in its physical and chemical properties, so as to fit it for the purposes of repairing the waste which is perpetually going forwards in the system. By the action of these parts the aliment is converted into a pultaceous mass, of a white colour and sweet taste, called chyle, which is the immediate agent of nutrition; and it is found, that in the same individual, or at least in the same class of animals, nearly the same kind of chyle is formed, whatever were the substances employed in diet. A more complete account of the process of digestion will be found in our article PHYSIOLOGY; but, at present, we may remark, that there is reason to believe that all the substances, before they can be converted into chyle, are reduced to a state of very minute division, if not of solution; that new chemical combinations take place between their particles; and that by some means a separation is effected between those parts that are adapted for forming chyle, and those which are rejected from the system in the fæcal state. As the ultimate elements of animal and vegetable substances are considerably different, the changes which they undergo must be so likewise, some bodies being capable of affording a larger proportion of chyle than others, and perhaps also of a different quality.

The ultimate elements of which all animal substances are composed are the same, although they exist in different proportions, but they differ from vegetable substances principally in containing more azote and less carbon. With respect to the primary compounds which enter into animal substances, they may be comprised under the following heads: muscular fibre, membrane, fat, albumen, and jelly. These differ from each other in three circumstances, which may be supposed to affect the process of digestion, their chemical composition, the state of aggregation of their particles, and the degree in which they are acted upon by the stomach. It might be supposed that those substances must generate chyle with the most facility, which approach the most nearly to it in their chemical composition, and to a certain extent this is probably the case; but it appears that their physical composition has a considerable influence on the process; and although the change which takes place in the stomach is a chemical change, yet it is so connected with the vital functions of the part, that something farther is necessary for perfecting the operation than the mere presence of the chemical elements. As the mechanical structure of the stomach, and the parts connected with, or subservient to it, is very various, so we find that particular classes of animals, and even particular individuals, are especially adapted for particular kinds of aliment. These differences seem, however, to attach more to the organs appropriated to the previous preparation of the food, the means by which it is comminuted or macerated, so as to render it proper for the solvent power of the gastric juice, although it is possible that the nature of the gastric juice itself may be different in different orders of animals. There is an important circumstance to be observed with respect to the human subject, in which it appears to differ from all other species of animals, that while they have each of them some particular kind of aliment, which is more peculiarly adapted to their respective natures, man appears to be better nourished by employing a variety of kinds of food. From the nature of their food, a division has been formed into the two classes of carnivorous and graminivorous, according as they feed upon animal or vegetable matter, while man seems to be naturally omnivorous, a circumstance which fits him for all countries and climates, and enables him to exist in a greater variety of situations than any other animal. It not only appears that he is the best nourished, or preserved in the most perfect health, by employing a proper mixture of animal and vegetable diet, but that a combination of two or more articles of the same class of substances appears more desirable than any one of them singly, even although it should be in itself more capable of supporting life. It appears, likewise, that the stomach performs its functions more completely when, besides what is essential to nutrition, it receives a quantity of extraneous matter, which may be regarded as diluting the actual nutritive substance, so that the articles which afford the greatest quantity of chyle, in proportion to their bulk, if taken without addition, do not appear to afford the diet which is best adapted for promoting the health. There are also great variations observable among individuals of the human species, depending upon peculiarity of constitution, derived from their parents, or the result of early habits and modes of life, besides numerous idiosyncrasies, for which it is often impossible to assign any satisfactory reason, which render it difficult to predict what kind of diet is the best adapted for any individual, or what would be the effect of certain substances when taken into his stomach. Any general rules that we can lay down must therefore be received with many limitations and exceptions.

Of the five primary compounds which form the basis of the articles of animal diet, muscular fibre, membrane, albumen, jelly, and fat, it is generally supposed that the muscular fibre forms the most perfect chyle, and is the best adapted for nutrition, provided the stomach be in a healthy state, and in the full posseesion of all its powers. Membrane is supposed to produce a smaller proportion of chyle, but, if presented to the stomach in a state of sufficient mechanical division, to be of easy digestion; while fat, on the contrary, is more nutritious, or produces more chyle, bulk for bulk, but is less easily digested, or, as it is said, is more apt to disagree with the stomach. Albumen, except as to its state of mechanical aggregation, is the same with membrane; while jelly is supposed to be the most easily acted upon by the stomach of all the animal compounds, or to be the most easily digested, but it affords a less quantity of chyle in proportion to its bulk. Of the articles which are commonly employed in diet, the flesh of quadrupeds consists of a mixture of muscular fibre, membrane, and fat; that of birds consists of muscular fibre, generally with less fat and less membrane; eggs consist solely of albumen; while fish contains a large quantity of albumen and jelly. We have already mentioned milk as a kind of intermediate substance between solids and fluids; its nutritive part is of the nature of albumen, while the different species of animal oils that, under various forms, enter into diet, are nearly similar to fat. There is not only a difference between the flesh of different kinds of animals, but between the same animal at different periods of its existence. In young animals there is a considerable quantity of jelly, and their whole texture is less firm; while, as they advance in age, the jelly disappears, or is converted into albumen and membrane, the fibre becomes denser in its texture, and the whole body acquires a firmer consistence.

The primary vegetable compounds which principally compose the nutritive part of the substances employed in diet are, vegetable gluten, farina, and mucilage. The first of these, in its chemical composition, and probably also in its power of generating chyle, is very similar to the muscular fibre; it is found almost exclusively in the seeds of plants, and particularly in those which belong to the tribe called *cerealia*, or the corns. It abounds the most in wheat; and it exists in this grain in such a state of combination, that properly prepared wheaten bread is generally regarded as the substance the most capable of supporting human life of any one body, either animal or vegetable. After wheat comes rice, barley, rye, and other grains, besides seeds of other kinds, as the pea and the bean, which contain a certain portion of gluten; and it is also found in some fruits and leaves, but in much less quantity than in wheat.

Next to gluten comes farina, which enters largely into the composition of seeds, both increasing their power of nutrition, and rendering them better adapted for the action of the stomach; while in roots which are without gluten, the farina is the most important ingredient: this is especially the case with the most valuable of all roots, the potatoe. The most nutritive fruits consist of farina, especially the different species of nuts, some of which, as the chesnut, compose an important article of diet in the southern countries of Europe. The fruits of the palm tribe, particularly the date, contain a large quantity of farina; and it enters largely into the composition of the cucumber, melon, and other similar articles, which contribute materially to the food of the inhabitants of the warmer climates.

Mucilage or mucus, is the third great constituent of vegetables, which gives them their nutritive properties, and there is perhaps no vegetable which does not contain a greater or less quantity; it forms a considerable proportion of some roots and fruits, and is the principal ingredient in the leaves and stalks of plants. As it is commonly used, it is likewise combined with a large quantity of water, and, bulk for bulk, is supposed to be less nutritious than either gluten or farina, although, when it is employed in a more condensed state, as in the form of gum, its power of supporting life is said to be very considerable. The largest land animals are generally those which feed upon the stems or leaves of plants, and they must therefore acquire their nourishment principally from mucilage; their stomachs are consequently very capacious, and their organs are so formed as to enable them to take in large quantities of food in a short space of time.

Besides gluten, farina, and mucilage, which compose the main proportion of the actual bulk of vegetables, there are other ingredients, which are probably very nutritive, but which must be regarded as peculiar or specific substances, belonging to certain tribes of vegetables only, not forming any of the absolute bulk of the plant, but lodged in cavities, especially adapted for their reception. Of these the most important are oil, sugar, and acids. Vegetable oil is principally found in certain seeds and fruits[*]; it is usually combined with farina, as in the seeds of many of the tetradynamian plants, and also in several of the nuts, especially the cocoa-nut, but in the olive it is more connected with mucilage: in many of the seeds, it is either itself so acrid, or is so combined with an acrid substance, as to render it incapable of being employed for nutrition; but in the oleaginous fruits it is generally considered as materially contributing to their nutritive powers, although to delicate stomachs, or to those not accustomed to it, it is not easily acted upon by the gastric juice. In a separate state, chiefly as procured from the olive, it is very generally employed by the inhabitants of the warmer climates instead of the solid animal oils, and is considered to be more easy of digestion.

But of all the primary vegetable compounds, there is none which is supposed to be so nutritive as sugar. This substance is found occasionally in almost all the parts of plants, and is probably an essential constituent of the sap. It is found abundantly in certain fruits and roots, especially the carrot and beet, but the source from which we generally obtain it, as an article of diet, is from the juice of the *arundo saccharifera*. Although it is usually employed rather with a view of rendering our food agreeable to the palate, than for the direct purpose of increasing its powers of nutrition, yet it is generally understood that it possesses this property in a very high degree, although, like the muscular fibre, and the vegetable oils, it is not well adapted for the powers of digestion, when taken into the stomach without addition, or even if it forms a very large portion of our food. We may remark, that a species of sugar, nearly similar to the vegetable sugar in all its properties, both physical and chemical, exists in milk; and it may be presumed that it contributes to the nutritive powers of this fluid. The last primary vegetable compounds which we mentioned are the acids; they are almost exclusively confined to the fruits, and contribute greatly to their agreeable effect upon the palate, especially in the warm climates, where they are the most abundantly produced. There is reason to believe that a due proportion of vegetable acid promotes digestion, especially the digestion of vegetable matter; and they possess the valuable property of very effectually quenching the thrist; but it may be questioned whether they are properly nutritive, or actually possess the power of generating chyle.

Besides what we have enumerated, there are other primary combinations, which contribute to nutrition, but which exist in small proportion only, as vegetable jelly, which is found in several fruits, and in some roots and leaves, and a substance considerably resembling albumen, which forms a large proportion of the bulk of certain seeds, generally in combination with oil, as in the almond. As to the ligneous part of plants, whether existing under the denser form of wood, or in the less compacted state of a network of the fibres, giving their different form to vegetables generally, it is doubtful whether it be capable of affording chyle, or in any way of contributing to digestion; and with respect to the resinous or extractive bodies of all descriptions, which exist in plants, they fall under the denomination of drugs or medicines, and have been treated under their respective classes, in the article MATERIA MEDICA.

We now come to the second great division of the substances used in diet, liquids or fluids. With respect to the purpose which they serve, it may be regarded under two distinct points of view, as tending directly to promote digestion, or as merely employed for quenching thirst. It is necessary to observe, that there are many articles of diet, where, by the processes of cookery, various solid substances are diffused or dissolved in water, such as broths and gruels of all kinds; these, so far as they differ in their effects from the solids which enter into their composition, must be considered as indebted for their properties to the water with which they are combined. Before we enter upon the consideration of particular kinds of liquids, it may be proper to observe, that mere dilution appears to be very favourable, if not absolutely necessary to digestion. All individuals, however they may differ in other respects, agree in employing along with their nutritive food a quantity of liquid; and when, under particular circumstances, it has been found impossible to procure the requisite supply, the sufferings and distress occasioned by this deficiency, have been even greater than from the actual want of food. It is not easy to assign the cause of this necessity, but it may be conjectured, that as a great proportion of most of the component parts of the body consists of water, so, in order to preserve their physical and chemical state, a regular supply of it must be afforded to the digestive organs. It is likewise probable, that a certain quantity of fluid is useful in mechanically separating the fibres or the particles of the solids, and thus rendering them more soluble in the gastric juice; and it is also not improbable that the chyle, when in a very fluid state, will more readily enter the vessels and the absorbents, and be conveyed with more ease to all parts of the system. Besides this general property of dilution, and the grateful effects of liquids in removing thirst, it is presumed that their only other operation is to favour the general action of the stomach, so as in some way or other to promote digestion, without actually affording any real addition of chyle. This may be supposed to be accomplished by producing a due degree of action in the extremities of the vessels or the glands, with which the interior of the stomach is lined, and which secretes the gastric juice. Without contemplating the presence of any specific disease, the consideration of which will belong to another part of our article, we may suppose them to suffer from a want of excitement, and that a proper degree of stimulus will bring them to the requisite standard. There is, indeed, a farther effect which may follow from the use of liquids: The mass of alimentary matter, when received into the stomach, undergoes a certain chemical change, probably somewhat resembling fermentation, which we find is extremely liable to be affected by apparently very slight causes; sometimes an acid is generated, sometimes it acquires a peculiar acrid state, and at other times it emits gas in great quantities. Now, it is probable that these morbid changes in the food, during the process of chylification, may be counteracted by the addition of certain liquids that are mixed with our diet, some of them possessing properties that appear to correspond with the supposed changes that take place in the stomach.

The liquids used in diet, with the exception of simple water, which acts as a mere diluent, may be arranged under the heads of vegetable infusions, fermented liquors, and distilled spirits. Of vegetable infusions, the principal that are employed in this country are tea and coffee, which, in most ranks of life, compose the basis of one, and frequently of two of our daily meals. There has been much controversy respecting the effect of these articles. When they were first introduced, they were vehemently condemned, and a description of their injurious effects was drawn up, which we now regard as absolutely ridiculous. Upon the whole, the present opinion is, that there are certain peculiar constitutions on which they act unfavourably; and perhaps the same unfavourable effect is in all cases procured, if they are taken in too concentrated a state; but, to the bulk of mankind, they appear to afford a salutary beverage, and to promote digestion, probably by their action upon the mass of alimentary matter in the stomach, in the way in which we have explained above.

The two other species of fluids, fermented and spiritous liquors, in some respects resemble each other, especially in the remarkable powers which they exercise over the nervous system, in consequence of the alcohol in them, which is denominated intoxication. Their action is directly stimulating, and within certain limits, with respect to the bulk of mankind, under the circumstances in which they exist in the present state of society, it is generally considered as not unfavourable to health. They differ, however, in one essential particular, that fermented liquors contain the alcohol in a much more diluted state, and also united to a proportion of mucilaginous and saccharine matter, which renders them, in some measure, nutritive, and in a considerable degree prevents the injurious effects which always arise from a long continued use of distilled spirits. Our conclusion, therefore, is, that fermented liquors, properly prepared, and taken in moderate quantities, are generally salutary; but that the habitual use of spiritous liquors is always to be avoided, and that they should never be employed, except as articles of medicine, or forming part of a plan of medical treatment.

It now remains for us to make a few remarks upon the effects of cookery on food. All nations, except perhaps some in the very lowest stages of barbarism, have agreed in subjecting their food, before it is employed in diet, to some kind of operation, generally through the agency of fire, by which its properties are materially altered. One effect of these processes is, to render the food more agreeable to the palate, which is produced principally by the mixture of different ingredients, or by making some change in their consistence. But besides this, which may be regarded rather as a means of gratifying luxury, than of promoting health, we may conclude that the simple application of heat to both animal and vegetable substances, renders them better adapted for the formation of chyle. Whether this be done by the application of a naked heat, as in roasting, or through the medium of water, as in boiling, an important effect ensues; the aggregation of the substance is partly broken down, and its component parts are reduced to a state in which they are more easily dissolved. A farther effect is also procured by the processes of cookery; certain ingredients, which are originally in a fluid state, become coagulated, and in this way rendered more proper for undergoing digestion. The first of these effects is entirely mechanical in its nature, while the latter probably acts more in a specific manner, which can only be referred to the vital action of the organ. It is not necessary to employ any long train of reasoning, or to adduce a number of facts to prove, that whatever breaks down and resolves the texture of substances, renders them more capable of digestion; in the different tribes of inferior animals, we always find that some apparatus is provided for this purpose, exactly adapted to the nature of the food which is to be employed, but in man, whose physical powers are often inferior to those of other animals, the exercise of skill and contrivance enables him to remedy many of his natural deficiencies; he therefore employs cookery, which is not necessary for other animals, as the means of supplying the necessities of his corporeal structure. Partly from the original formation of his teeth, and partly from the imperfections to which they are so liable, his powers of mastication would be inadequate to the complete comminution of his food, if it were taken in its recent state. But it appears that both animal and vegetable food, even if reduced to a pulp, are not so digestible as the same kind of food after the process of boiling; and the reason of this appears to be, that the heat coagulates the fluids contained in the substances which are capable of undergoing this operation, and thus coincides with the action of the gastric juice, the first effect of which upon these fluids, when they are received into the stomach, is to convert them into a solid form. By cookery, likewise, when it is not carried to an excessive degree of refinement, the articles of diet are rendered more proper for the action of the stomach, by mixing together different ingredients, and thus forming a compound which is more salutary than the substances would be of which it is composed, if they were taken separately. This is particularly the case with sugar, animal and vegetable oil, and other analogous bodies, which, although highly nutritive, are not well adapted for the action of the stomach, when received into it in an unmixed state. There are very few subjects in which the caprice of mankind is more conspicuous than in the preparation of their food: those articles which some nations regard as the highest luxury, and which they purchase at the most enormous expense, are to others equally disgusting; and even among individuals of the same country, who have been brought up in the same general habits, there are certain peculiarities of taste which appear the most whimsical and extravagant. Independent of fancy or the effects of custom, we also perceive daily examples of very remarkable idiosyncrasies, by which certain persons are rendered incapable of digesting substances, which to others are the most salutary. It is often one of the most difficult parts of the duty of the medical practitioner to give the proper directions respecting the diet of his patients; for he has not only to guard against all these peculiarities, but he has likewise to take into account the singular anomalies that are frequently produced as the consequence of disease.

After these brief remarks upon the nature of the substances employed in diet, we should next proceed to offer some observations upon the effects of the quantity of the food taken, or upon repletion and abstinence; but as we are necessarily obliged to study brevity as much as possible, we shall endeavour to bring in what we have to say on this topic in the last division of this article; and we shall likewise reserve for the same place an account of the diet which is proper for particular diseases. The only remaining subject connected with dietetics is an account of the kind of food especially adapted for particular ages and constitutions, a topic of great interest, and which involves many important considerations. For the reasons which have been assigned, we must, however, very much curtail what might be said upon this point: part of it will be more advantageously discussed under the head of PHYSIOLOGY; and we shall necessarily be led to offer a number of remarks concerning it, when we treat of the diseases which are especially incident to particular periods of life.

With respect to different ages, the progress of human life, so far as the action of the digestive organs is considered, may be divided into six stages, that of infancy, childhood, youth, manhood, decline, and decay. In infancy, the organs and functions are still in an incomplete state, the instruments for masticating the food are not yet in existence, nor is the animal in possession of those mental powers which would enable him to employ them. The act of deglutition is, however, performed with perfect accuracy from the first moment of birth, and that of suction is, likewise, either bestowed instinctively, or is learned with great facility; while the gastric juice is so far possessed of its appropriate qualities, as to coagulate albumen, and afterwards to convert it into chyle. To meet the exigencies of the case, nature has furnished the breast of the mother, after parturition, with a supply of food, precisely adapted for the infant, so that, both from analogy and from experience, we can have no doubt that, during the first months of existence, the mother's milk is the diet best fitted for her offspring. By degrees, however, this fluid ceases to be secreted; the teeth, at the same time, are formed, and the period of childhood comes on. This combination of circumstances points out to us the propriety of employing food of a more solid kind; and the conclusion that we might draw from it is farther confirmed, by the necessity of a more substantial diet, in order to supply the urgent demand for the rapid growth of the body. We find, however, that the functions of the stomach are still in a state that requires great circumspection; the processes of chylification and sanguification are performed with rapidity, and in proportion to the capacity of the organs, the products are in large quantity; but the system is not in a condition to bear much excitement, and the inflammatory action is readily induced: hence, the food should be simple, and given at short intervals, and while it contains a plentiful supply of the elements of chyle, it should be of the mildest nature. Milk, with the different kinds of farinaceous vegetables, in proper quantities, and prepared of a due consistence, may comprize the whole variety of alimentary matters which are suitable for the age of childhood.

In the next stage, that of youth, the necessity of a copious supply of nourishment still continues; and there is still the tendency to an inflammatory state in the system, although in a less degree; so that now a portion of animal food may be mixed with the vegetable diet, the meals may be taken at longer intervals, and a greater variety of articles may be employed. It is still, however, necessary to guard against all direct stimulants: they are not necessary for the production of the chyle, and although their injurious effects may not be immediately perceptible, yet they must have an unfavourable tendency, and must serve to lay the foundation for a morbid state of the digestive organs; and what is perhaps still more important, they lead to habits of self-indulgence, equally fatal to the moral and physical welfare of the individual. At what period of life we may commence with the use of fermented liquors depends upon a variety of circumstances, and indeed scarcely admits of any general rule; but it may be remarked, that as long as the constitution is healthy, and the functions are performed with due vigour, there can be no advantage derived from them, and if they are at all employed, it must be more from indulgence than from necessity. In the decline of life, and still more in the last state of decay, the use of stimulants of all kinds is indicated by the state of the organs, which, now becoming torpid and callous to the usual impressions, are slow in the exercise of their accustomed functions, and require a degree of extraordinary excitement, in order to bring them to the standard of health. Food should be selected which contains the greatest proportion of nutritive matter, and of a kind the most easily assimilated. We have now no longer to dread the access of inflammation, but we have to guard against the opposite state of languor and inaction; wine is therefore now as necessary as it was before improper, while a liberal use of the various condiments not only stimulates the palate and stomach, which require this additional assistance, but also promotes the secretion of the gastric juice, and probably corrects the morbid changes which the alimentary mass is liable to experience.

SECT. II. *Arrangement of the Materia Alimentaria.*

Some authors have referred the consideration of the different articles that are employed in diet to the head of Materia Medica, but we think that it belongs more properly to this department of medicine; and we accordingly restricted the use of the term Materia Medica to indicate those substances which are only employed as medicaments. The most common, and perhaps, on all accounts, the most commodious method of classing the articles of the Materia Alimentaria, is according to what are called the three kingdoms of nature: no difference of opinion can arise respecting the situation which each individual substance ought to occupy in the arrangement; and, for the most part, their physical properties and their qualities, as nutritive bodies, have a correct and obvious connexion with the class to which they belong. This holds good, in almost every instance, with respect to the animal and vegetable kingdoms; and it is from these alone that every substance which can properly be said to be nutritive is derived. With respect to those that are neither of animal nor vegetable origin, although a more scanty and less definite class, there can be no impropriety in uniting them all under one division, even although we may be inclined to regard them as a kind of appendage to the two former.

We have already had occasion to make the remark, and shall more fully insist upon it, when, under the article PHYSIOLOGY, we consider the subject of digestion, that no substance can properly be regarded as nutritive, or directly affording the materials for nutrition, unless it be an organized body, consisting essentially of oxygen, hydrogen, carbon, and azote, combined together in certain proportions. This character belongs exclusively to the products of the animal and vegetable kingdoms, which alone form organized compounds; with respect to other bodies, which are not capable of organization, or which belong to the mineral kingdom, although they may be useful in promoting the process of digestion, yet they do not serve for the immediate purpose of nutrition; they operate either by exciting the action of the digestive organs, or by rendering the substances themselves more digestible. As an example of the first class, we may instance common salt, and as an example of the second, we may adduce water, when forming the vehicle for the different kinds of soups and gruels.

The substances from the animal kingdom which are commonly employed in diet, whether we consider them with regard to their effects upon the stomach, or according to the relation which they bear to other substances belonging to the same class, may be commodiously arranged, in conformity with the popular division, into the three classes of quadrupeds, birds, and fishes: to this we may add a fourth class, consisting principally of the mollusca and crustacea, and a fifth, composed of animal fluids. With respect to the general properties of animal, as differing from vegetable substances, the following may be pointed out as their most distinguishing characters: First, bulk for bulk, they afford a greater quantity of nutritive matter than vegetables; secondly, except in stomachs that have been trained to it by long habit, mere animal diet appears to be less proper for maintaining the healthy state of the digestive organs than a mixed diet, or even than one composed entirely of vegetable matter; thirdly, the effect of a diet consisting entirely of animal matter appears to be, to increase the contractility of the muscular fibre, and the sensibility of the nervous system; and, in general, if not carried to excess, it seems to operate by exciting all the powers and faculties, and carrying their energies to the highest pitch of perfection. The older physiologists insisted much upon the different chemical conditions of the components of the body, according to the nature of the diet employed: they supposed that animal diet produced an alkalescent state of the system, and that vegetable diet, on the contrary, tended to the formation of an acid state. But it is not to be doubted that, in forming these opinions, they were influenced much more by theory than by an actual reference to facts. They imagined that the operation of the stomach was similar to fermentation or putrefaction, and that, as in these processes, animal matter tends to generate an alkali, and vegetable substances an acid, so it was taken for granted that the same thing occurred in the stomach. Perhaps, to a certain extent, this may take place, at least with respect to the effect of a mere vegetable diet, from which, to a stomach unused to it, or when the food has been taken to excess, a peculiar acid appears to be formed during the process of digestion. We have not, however, the slightest evidence for believing that this acid state extends beyond the contents of the stomach, not even to the fluids generally, and still less to the mass of the solids. In ordinary cases, the acid of the stomach increases the action of the intestines, and is carried off in that direction. With respect to the alkalescent state, as being the result of animal diet, it appears to be entirely hypothetical, and to be founded altogether upon an erroneous conception of the chemical state of the components of the body. Most of the fluids, in their healthy condition, as the blood generally, and perhaps all the albuminous secretions and excretions, naturally possess an excess of alkali; and it may be questioned whether we have one single well authenticated fact, which would lead us to conclude that this alkalescence can be increased by any alteration in the state of the diet, or by employing any peculiar kind of food.

When, in the revolution of opinions, chemical reasoning was less generally had recourse to in explaining the phenomena of the living system, the different effect of animal and vegetable diet was referred entirely to the action of the substances upon the vital powers, and was eventually ascribed merely to the greater or less degree in which they were capable of stimulating or exciting these powers. To a certain extent this may be allowed to be true; and we have, indeed, every reason to believe, that it is much more to their vital action, than to any mechanical or chemical operation, that the effect is produced. Yet, at the same time that we make this concession, we must observe, that the language employed by these physiologists amounts to little more than a general expression, which conveys no determinate meaning, or, at most, that it merely conveys to us the knowledge of a general fact, without throwing light either upon its cause, or upon the nature of the operation. The simple fact, stripped of all hypothesis, seems to be, that, in the digestion of animal food, a greater degree of that action is necessary, whatever it be, which constitutes the essential part of the function of digestion. This increased action of the stomach is extended to the arterial system generally: the heart and arteries pulsate more powerfully; the circulation is carried on with more rapidity; and from this circumstance all the functions become more excited, and are performed in a more vigorous manner. In a febrile state of the system, or even without the actual presence of fever, when the contractility and sensibility are in a condition to be easily called into excessive action, the use of animal food is found, by experience, to have more power in producing this excessive action than a diet composed of vegetables; and it is likewise found, that a much less quantity of animal food is capable of producing the same degree of effect.

Of the quadrupeds that are generally employed for food among the nations of Europe, and are kept in a domesticated state for this purpose, the principal are the ox, the sheep, and the hog; to which may be added some that are more sparingly employed, and which remain more or less in their natural wild condition, such as the deer, the hare, and the rabbit. The flesh of these animals, especially the two first of them, both with respect to the action upon the stomach and its power of nutrition, seems to possess considerably different properties, according as it is employed while they are young, or after they have arrived at their mature growth. The qualities of beef and mutton differ nearly as much from those of veal and lamb, as any one of the articles differ from any other of them. If we attempt to arrange these different substances, beginning with those that are most nutritive and stimulating, and proceed to those that are the least so, we may perhaps place them in the following order. The flesh of the ox will stand first on the list; to this will succeed that of the sheep and the deer; perhaps the flesh of the hare should come next in order, or at least with regard to its stimulating, if not with respect to its nutritive power. Pork, on the contrary, ought probably to be considered as one of the most nutritive of all these substances; but, in consequence, as it seems, either of the quantity or the quality of the fat and oil with which the fibre is united, it is less easily digestible. The flesh of the ox and the sheep, while in the state of veal and lamb, is generally regarded as less stimulating than when the animals are at their full growth; but it is esteemed less nutritive, and, in many stomachs, it seems even to be less digestible. The rabbit appears to hold the same relation to the hare, in its qualities as an article of food, that veal bears to beef. It is admitted that there is great uncertainty in any general remarks that we can make of this kind; we seldom find two persons who would agree entirely, on all points, respecting the effect of these different substances, or whose organs of digestion would operate upon them entirely in the same manner.

The flesh of birds, in most of the large communities of Europe, makes but an inconsiderable part of the animal food which is employed in diet, and is regarded chiefly as an article of luxury. The number of birds that are occasionally used is very considerable; but, without entering into an enumeration of the whole of them, and regarding them not as objects of classification in natural history, but according to their effects upon the digestive organs, we may place them in three divisions. First, the gallinaceous birds, principally composed of the common dunghill fowl, with all its varieties, and the turkey. The second is a more miscellaneous class; it embraces most of the birds which, in this country, are denominated game, as well as some others, which, although differing from them in their habits and state of domestication, resemble them in their effect upon the stomach; the principal of these are the pheasant, the partridge, the pigeon, the snipe, the woodcock, and the different kinds of moor-fowl. The third class consists chiefly of the anserine tribe; the goose and the duck, both in their wild and in their tame state; the widgeon, the teal, and some other birds that live in the water or among the fens, and feed upon insects. Although there may be some doubt in which division certain birds should be placed, still we apprehend that they possess each of them distinguishing characters, which sufficiently authorize the general principle of the arrangement. The birds of the first class are always kept in a domesticated state, and are fed expressly for the purposes of the table, by which their flesh must be considerably altered from its natural qualities. As we employ it, it is mild, digestible, and nutritive; so that there are, upon the whole, few substances that are so generally agreeable to all stomachs, or which furnish a larger proportion of chyle. The transition from the gallinaceous birds to those which we have placed in our second division is very gradual; and, with respect to some of them, as, for example, the pheasant, it might, with almost equal propriety, be placed in either class. The character of the partridge is more marked; and from this we pass to the others which possess more specific qualities. The birds of this class are less mild, and perhaps rather less nutritive than the gallinaceous: they all of them possess more or less of a specific flavour, which renders them peculiarly grateful to the palate; and they are, upon the whole, considered as not less digestible than those of the first class: they are, however, more stimulating, and are therefore esteemed less proper for food, where it is an object to produce as little excitement of the system as possible. The third class, the anserine birds, differs still more from the gallinaceous: they are generally less digestible and less adapted for the purposes of nutrition; while they are equally, or even still more stimulating, than those of the second class.

The varieties of fish that are employed in diet are probably still more numerous than the birds, and are derived from a greater number of different genera. We shall, however, only consider them as articles of diet, and not as objects of natural history; and we shall arrange them into two classes only, depending upon the quantity of oil which they contain interspersed through their substance. In the first class we shall place those that are entirely without it, such as the cod, the haddock, the whiting, and a great variety of white flat fish, as the turbot, the sole, and the flounder. In the second class we place the fish that contain a considerable quantity of oil, which renders them more sapid, and perhaps more nutritive, but, at the same time, less easily digestible. The salmon, the mackarel, the herring, and the eel, are some of the most common of the oily fish. The first are among the most mild substances of an animal origin which are employed in diet, and, for the most part, are easily digestible, and considerably nutritious, while the fish that we have placed in the second class are many of them difficult of digestion, and peculiarly liable to disagree with certain stomachs that possess any idiosyncrasy, or where the digestive organs are merely in a weak state. With the exception of some fish that have specific properties, in consequence of the quantity or quality of the oil which they contain, the whole class may be regarded as possessing the characters of animal diet in a less marked degree than the flesh of either quadrupeds or birds.

The fourth class of substances taken from the animal kingdom, which are employed in diet in this country, are confined to some of the mollusca and crustacea. With respect to their qualities as articles of food, they may be arranged as they belong to one or the other of these orders; the first being comparatively mild and simply mucilaginous, of which the principal are the oyster and the cockle, the latter being more sapid, and partaking more of the oily nature, as the lobster, the crab, and the shrimp. Almost exactly the same remarks may be applied to these as to the two kinds of fish; the first being, for the most part, easily digestible, and very nutritious; the latter being less digestible, and considerably more stimulating.

The fifth class of animal substances still remains to be noticed; those which we have called animal fluids, because they either naturally exist in the fluid state, or are more generally employed in this form. To this class belong all the various preparations of soups and jellies which enter so largely into our diet: but as these do not seem to differ essentially from the substances which enter into their composition, when used in their solid form, we shall not dwell more particularly upon them, but shall confine our attention to the natural fluids, of which the most important is milk. There are very few nations, whatever be their habits in other respects, and their state of civilization, who do not agree in making milk a part of their customary food. Without entering into a minute detail of its chemical analysis, milk may be said to consist essentially of albumen and oil, diffused or suspended in a large proportion of water, and united to a quantity of sugar. The proportion of the albumen and the oil differs very considerably in the milk of different animals, and also in the milk of the same animal at different times. The milk of the human female contains very little albumen; and as this is the ingredient which is the most difficult of digestion, so we may perceive why the milk of the mother is better adapted for the nourishment of the infant than any preparation of the cow's milk. The two principal ingredients of milk, the albumen and the oil, form the basis of cheese and butter; the former consisting of albumen, united to more or less of oil; the latter of the oil nearly in a pure state. Eggs are an article of diet, which, in their nature and properties, are very intimately connected with milk. The white of the egg, as its name imports, consists almost entirely of albumen: the yelk of an albuminous substance, united to a quantity of oil. Both milk and eggs are highly nutritive, and, in general, are sufficiently easy of digestion; yet we meet with not unfrequent instances of peculiar idiosyncrasies, in which they cannot be employed as food; and it would appear, that neither albumen nor oil are in themselves considered so easy of digestion as the muscular fibre.

We now proceed to the consideration of vegetable diet. The articles taken from the vegetable kingdom, that are commonly employed for food in the different countries of Europe, and among other nations that have arrived at any considerable degree of civilization, may be arranged under five heads: 1. The leaves and stalks of plants; 2. Roots; 3. Fruits; 4. Seeds; and, 5. Preparations from different parts of plants. We have already remarked, that the most important of the proximate principles of vegetables which render them fit for nutrition, are gluten, farina, mucilage, oil, and sugar; and, with respect to the four first, at least, of the above classes, it would seem that both their nutritive and their digestible qualities depend entirely upon the proportion in which these several ingredients enter into their composition, or the manner in which they are combined together. Perhaps the nutritive powers of the different substances will stand in the order of sugar, oil, gluten, farina, and mucilage; but the two first articles, sugar and oil, although capable of furnishing the elements of chyle in the greatest proportion, bulk for bulk, are not easily digestible in a separate state; and it is probable that the same remarks will apply, in a less degree, to gluten. We may therefore conclude, that, upon the whole, no ingredient, in its separate state, will be found so well adapted for the action of the stomach as farina; but, as they are seldom used except as forming part of a vegetable compound, it will be more to our purpose to consider them as they exist in their various natural combinations.

The nutritive matter of leaves and stalks consists principally of mucilage, in some cases united to a portion of farina, and occasionally with a little oil and sugar. A large quantity of water generally enters into their composition; so that, in proportion to their bulk, they are among the least nutritive of the vegetable substances that are employed in diet. Many of them are of a nature peculiarly liable to undergo the fermentative process; and, during digestion, they frequently cause flatulence, and in various ways disorder the functions of the stomach. Many of the plants of which we employ the leaves and stalks in diet, are of the Tetradynamian class, which, in addition to the usual elements of vegetables, contain a quantity of azote; in this way making some approach to the nature of animal matter. It does not exactly appear in what state of combination the azote exists, or whether it actually renders the substance either more nutritive or more digestible.

The roots of plants are, upon the whole, considerably more nutritive than the stalks and leaves, and they compose a much more important part of our diet. Of these, the most valuable, with respect to all its economical properties, and the one which is the most extensively employed, is the potato. It consists of a mixture of farina and mucilage, the proportion of which varies very much in the different varieties, but which in all of them compose a compound at the same time easily digestible, and very nutritive. Besides mucilage and farina, some of the roots contain a considerable quantity of sugar, especially the beet and the carrot, which may be supposed to render them more nutritious; but, in consequence probably, of their being less farinaceous than the potato, they seem less proper to compose a large proportion of our diet.

In all cultivated countries fruits of various kinds are employed as articles of diet; and, in warm climates, they form even a very considerable proportion of the food of the inhabitants. According to the nature of their composition, and their supposed effect upon the digestive organs, they may be arranged under the four divisions of mucilaginous, farinaceous, acid, and oily. The two former, of which the cucumber and the chesnut may be adduced as examples, probably do not differ very essentially from some of the articles that have been already enumerated. Like them, their nutritive properties, and their capability of being easily digested, must depend partly upon the quantity of mucilage and of farina which they contain, and partly upon the proportion of water with which it is united, or upon the state of combination in which their ingredients exist, by which they are rendered more or less soluble in the gastric juice. The acid fruits compose a very numerous class; which, although they do not form any large proportion of the nutritive matter received into the stomach, yet they are frequently taken in such quantity as to have a considerable influence upon the state of the digestive organs. Many of them contain a great quantity of sugar, when they must no doubt prove nutritive; but, for the most part, they are rather to be regarded as producing a grateful effect upon the palate, or promoting the digestion of other substances, than as themselves contributing directly to the formation of chyle. In the warm climates, the acid fruits are particularly valuable for their power of quenching thirst, or giving to the body a general sensation of coolness, which materially contributes to counteract the oppressive effects of the high temperature of the air. Those that contain a large proportion of acid must have a considerable action upon the digestive organs; and it is probable, that, by their tendency to preserve the bowels in a lax state, they may prevent or mitigate the diseases to which the body is peculiarly liable in warm climates. The oily fruits, particularly the olive, form a very important class of vegetable products, which enter largely into the diet of certain countries; but as the oil which they contain is generally employed in a separate state, its effect upon the stomach will more properly belong to the fifth class of vegetable substances.

In all countries, both in ancient and modern times, where civilization and agriculture have made any considerable progress, the most important articles of vegetable diet have been derived from the seeds of plants. Proceeding upon the same principles which we have before adopted, we may arrange these bodies under three heads; the cerealia, or the seeds derived from the different species of grasses, constituting the corns, the leguminous seeds, and the nuts. Of the cerealia, whether we consider the actual nature of their ingredients, or the extensive use that is made of them, the most important are, wheat, rice, maize, rye, barley, and oats. Wheat, in every respect, stands pre-eminent. It contains the largest proportion of gluten; the vegetable principle which bears the nearest resemblance to animal matter, both in the nature of its chemical composition, and its effect upon the digestive organs. Gluten is found in small proportion in some other of the corns; but the rest of them owe their nutritive power principally to the farina which they contain. For the most part, the seeds of this description are not eaten until they have undergone various culinary operations, of which the most important, and the most complicated is their formation into fermented bread. By means of the panary fermentation, a very great change, both physical and chemical, is introduced into these substances; their texture and consistence is totally altered; and it is probable, that of the primary compounds which enter into the seeds, very few retain their former properties after they have been converted into bread. The result of the operation, especially when we employ wheat, is a substance highly nutritive and digestible; which is, perhaps, better adapted to the action of the stomach, under all circumstances, and in all constitutions, than any one article, either animal or vegetable, which is used in diet. The cerealia are likewise used for the formation of a great variety of decoctions and infusions, and for a large class of substances which form an important part of our diet, in which the seeds, after being reduced to the state of fine powder, are taken in a more or less consistent or solid form, without having gone through the process of fermentation. In this case, the flour is mixed with a quantity of albuminous, oleaginous, or saccharine substance; and, when prepared in a proper manner, and made subservient rather to the purposes of nutrition than of mere luxury, forms very digestible compounds, and which are, at the same time, peculiarly grateful to the palate.

The leguminous seeds form an important article of diet in some countries. They bear a general resemblance to the cerealia, both in their chemical and their dietetical properties, although they are inferior to them both in their power of nutrition and in digestibility. They are supposed to be peculiarly liable to undergo the fermentative process when they are received into the stomach; and, except when young and tender, they do not seem so well adapted for general use as other vegetable substances. The oily seeds, constituting the nuts of all descriptions, are rather employed as articles of luxury than of absolute nutrition. They are, for the most part, of difficult digestion; a circumstance which appears to depend more upon the mechanical aggregation of their parts, than their chemical composition, for when they are rubbed down into the form of mucilage, they become much more easily acted upon by the gastric juice. It has been lately discovered, that, in some of the oleaginous seeds, the oil is united, not, as was formerly supposed, to farina, but to an albuminous substance, in all respects similar to that of animal origin. Many seeds of this description contain a large proportion of sugar, as the almond and the cocoa-nut; they are peculiarly grateful to the palate, and must be highly nutritious, when the solvent powers of the stomach are sufficient to act upon them.

We come now, in the fifth place, to give an account of the substances that are artificially prepared from plants; consisting either of some of the primary compounds separated from the other ingredients, or of new substances that are actually generated by some mechanical or chemical operation. Among the first, we may enumerate various forms in which the farina of plants is employed in diet, as sago, tapioco, and arrow-root, which, when united to a proper proportion of fluid, are highly nutritious, as they contain the most digestible part of the vegetable, deprived of all its extraneous matter. The fine flour of wheat—the state in which this grain is generally employed—may be considered as an artificial preparation, in which the gluten and farina are left, while the greatest part of the parenchymatous or ligneous matter is separated. Another article which is very extensively used in diet, and which must be considered as directly contributing to nutrition, although, perhaps, not generally employed with this intention, is sugar. It is supposed, that, bulk for bulk, sugar is one of the most nutritive substances that enters into our food; but, in its unmixed state, it is incapable of being digested, and requires a considerable quantity of other matter to be united with it, before the powers of the stomach can convert it into chyle.

With respect to artificial preparations of vegetable origin, we have already anticipated the mention of one of the most important of them, viz. fermented bread; a substance which must be considered as formed by a combination of certain mechanical and chemical operations, and not previously existing in the ingredients from which it is formed. Strictly speaking, all the products of cookery fall under this description, as being substances that have experienced some considerable alteration in the chemical and physical properties of their component parts. A remarkable change that is induced in certain vegetables, for the purpose of forming articles of diet, is the operation of malting; in which some of the cerealia undergo a kind of fermentation, when a proportion of either farina or mucilage is converted into sugar, which is afterwards, by a farther fermentative process, formed into the beverages that are called malt liquors. The change that is effected in our food by the various operations of cookery ,is perhaps not very thoroughly understood. As we have observed above, it consists partly in mechanically breaking down the hard and solid parts of the substances; but it appears, that, in some cases, a chemical change is also effected. Some of the original components are decomposed, and new ones are formed, which we may conceive are more digestible, or more nutritive, than the former. In highly civilized and luxurious countries, the operations of cookery are perhaps more directed to render the articles agreeable to the palate, than salutary to the stomach; but even in the rudest and most barbarous countries, we always find, at least with very few exceptions, that the inhabitants subject their food to the action of fire before it is received into the stomach.

We have now gone through the principal articles of both animal and vegetable food; a very important part of the subject still remains—the consideration of the fluids, or drinks, that are employed in diet. These may be regarded under two points of view: first, As merely vehicles for various solid matters; or as simply diluting them, and rendering them more soluble in the stomach: and, secondly, As substances which have some immediate and specific action upon the body, different from that which is caused by any of the articles of food; being taken either for the purpose of quenching thirst, or from their grateful effects upon the palate. The first class of these substances, such as soups and gruels of all kinds, we may consider as having been already discussed, when we were speaking of the solid substances which enter into their composition; and it will only remain for us to make a few observations upon the general effect of drinks, regarded merely in the light of fluids, without any respect to their specific nature, or peculiar properties.

It is an opinion, sanctioned by the general feelings of mankind, that a certain quantity of liquid is a necessary, or at least a very desirable, addition to the solid food which is taken into the stomach. Indeed, so far as the mere sensations are concerned, there are many facts which would lead us to suppose, that the extreme thirst that is produced by a total privation of fluids, is more intolerable than even the most urgent calls of hunger. And, besides these cases of excessive thirst, it would appear, that, in the regular course of things, a certain proportion of liquid essentially promotes the digestion of our ordinary food. In what way it acts we are unable precisely to determine; whether upon the stomach itself, or upon the substances taken into it. The fluid may be useful in disposing the alimentary mass to undergo the necessary change which fits it for ths process of chylification, or it may affect the glands of the stomach, so as to adapt them better for the secretion of the gastric juice, or it may act in a salutary manner upon the nerves and muscular fibres of the organ. The farther discussion of this subject will more properly belong to the article PHYSIOLOGY, where the nature of the function of digestion will be more fully discussed.

The second class of drinks, those in which the substances employed possess some specific properties besides that of mere fluidity, may be subdivided into two species; the first consisting of various vegetable decoctions or infusions, and the other of fermented or distilled liquors. We have already made some observations upon the nature of these various fluids, as articles of diet, which it will not be necessary to repeat; but it may be proper to offer some remarks on the effects of alcohol. The action of alcohol, both upon the stomach and the system at large, is a subject that has given rise to much discussion, as well with regard to theory as to fact; and it may still be considered as one of the points in physiology and in dietetics which is the least determined, and upon which the greatest variety of opinions exist. With respect to the first point, however, the most intelligent writers of the present day, and those whose opinions seem to have been formed by the most extensive deduction from facts and observations, regard the action of alcohol to be, in the first instance, stimulating to the system generally, or to belong to that class of agents which, in our systematic arrangement of the articles of the materia medica, we have denominated excitants. By excitants, we mean those substances which increase action generally, or augment the operation of all the primary functions which are essential to life. Whether, when employed in moderate quantities only, it be favourable to the powers of the stomach to be maintained in a constant state of gentle excitement, by means of stimulating substances taken into it, is a question concerning which very different opinions have been entertained. Perhaps it will depend more upon the peculiar condition of individuals, than upon any circumstance which respects the animal frame generally; but it may be certainly concluded, that this state of excitement, if it be at all admitted, should be in a very moderate degree, while the most fatal effects are daily experienced from its excess To those who are engaged in active corporeal employments, and whose digestive powers are in a good state, we shall commonly find, that malt liquors afford a beverage at once salutary and invigorating; the quantity of mucilage with which the alcohol is enveloped counteracting its pernicious effects. The same thing may probably be asserted of the light wines, or of the liquors prepared from other fruits, as cyder; except that the quantity of acid which they frequently contain is, in many constitutions, productive of an unpleasant operation upon the stomach and bowels. With respect to the stronger wines, we conceive that their habitual use is never necessary, and is generally hurtful; and that it should not be admitted, except in those cases where an excitant is immediately indicated, or where, from previous diseases, from some original weakness in the constitution, or from the approaches of old age, the powers of the system at large, and of the stomach in particular, require an additional stimulus to perform their accustomed functions. Still less is the employment of distilled spirits to be allowed as an article of diet. Their action upon the stomach and viscera is decidedly injurious, while their effect upon the system in general is most unfavourable, and of a nature which tends to undermine all the powers, mental and corporeal.

We have now considered all the substances which can properly be styled alimentary, either as affording the elements of chyle, or as immediately producing an effect upon the stomach, which is obviously favourable to digestion. There is still a numerous and important class of articles which are commonly employed in diet, but which seem to differ essentially from all those that we have examined, as well in their nature and properties, as in their operation upon the system. These are the bodies which have usually been styled condiments; by which we mean, certain substances that are mixed with the food, for the express purpose of rendering it more grateful to the palate. Condiments may be divided into three classes, the saline, the aromatic, and the acrid; the former of mineral origin, the two latter being derived from the vegetable kingdom.

Of the saline condiments, the principal is the muriate of soda, or common salt, as it is generally styled; a substance which is employed by all nations, whatever be their tastes or habits in other respects, and which is relished even by many of the brute animals. The efficient, as well as the final cause of this general relish for common salt, is a point which has been much discussed; but it does not appear that any positive conclusion has been obtained with respect to it. There are, indeed, many circumstances which seem to render it probable, that a due proportion of salt promotes digestion; but whether it acts upon the alimentary mass, or upon the vital functions of the stomach, is not ascertained. As a certain quantity of the muriate of soda is likewise found in the blood, and in many other of the animal fluids, it has been supposed, that at least one use of the salt mixed with our food might be, to afford a regular supply of it to those fluids. It must, however, be confessed, that our opinions upon this subject are little more than conjectural; and that, if we consider the general fact of the salutary operation of salt as established, we must at present acknowledge our ignorance of the manner in which it acts.

The aromatic and acrid condiments are derived from the vegetable kingdom. The former are almost exclusively the products of warm climates, as cinnamon, nutmeg, ginger, &c.; the latter are found in various parts of the earth; some of them, as pepper and capsicum, growing only in the torrid zone; others, as mustard, horse-raddish, &c. being natives of the north. The same remarks, in part, apply to the aromatics and acrids as to common salt. They are very generally relished by the inhabitants of all countries, and this in a way which would seem not to proceed altogether from their grateful effects upon the palate; for many of the acrids can scarcely be considered as possessing any qualities of this kind. There is a circumstance, with respect to the sense of taste, which must be noticed in this place, in order to explain the effect of substances of this description upon the palate. We refer to the power of habit in influencing or modifying our sensations; so that many of those substances which, in the first instance, are the least agreeable to us, become, by custom, almost necessary to our existence. We accordingly find, that we are in general more strongly attached to those articles that have some strong acrid or disagreeable flavour, than to such as are sweet and delicious; so that sugar becomes less relished than tobacco, or even than asafœtida, to those who have been long habituated to it.

The next of the general remedies which we have enumerated, is exercise. This has been in all ages considered as a very powerful agent in the promotion of health; and, by the ancients especially, was attended to with the greatest minuteness. In our historical sketch, we have had occasion to notice Herodicus, who expressly devoted himself to this department of the art, under the name of gymnastic medicine, and who seems to have held out bodily exercise as a cure for all diseases. But although he may have the merit of making the first accurate observations on the subject, and of carrying the system to a much greater extent than had been done before his time, he is probably to be regarded as an empiric, and is seriously complained of by Hippocrates, as having destroyed his patients by the indiscriminate application of his remedies. We find, however, that Hippocrates himself, Celsus, Galen, and all the most learned of the ancient physicians, were very loud in their commendations of exercise in the cure of diseases, and very minute in their directions for its use. It was not confined, as is the case in modern times, almost exclusively to the loco-motion of the body, either in walking or in riding; but a variety of games were practised by all ranks of society, in which health, and not amusement, was the professed object. In modern times, the effects of exercise have especially attracted the notice of different medical men; but it has been generally considered rather as a means of preserving health, or removing the general effects of disease, than as a remedy for particular complaints; although to this remark there are some striking exceptions, which will be hereafter mentioned.

Bodily exercise, as practised in modern times, may be divided into two kinds, of active and passive; the first consisting principally of walking, the second comprehending various species of gestation. The immediate effect of these two kinds of exercise upon the functions, appears to be considerably different. In active exercise, a great quantity of muscular motion is necessary, by which the action of the heart and arteries is excited; this causes the quicker transmission of the blood through the lungs, and a greater chemical change is effected in the air, more oxygen being consumed, and more carbonic acid generated; the temperature of the body is at the same time elevated, and the cutaneous and pulmonary exhalation is augmented. Passive exercise produces a very different action on the system; here, comparatively little muscular exertion is required, and the principal circumstance which can be supposed to affect the body is its mechanical agitation. By the agitation of the individual limbs, and even of the individual muscles, pressure is perpetually exercised on all parts in succession; and in this way the veins which lie near the surface, or immediately below the muscles, have their contents squeezed out from the parts pressed upon; while in consequence of their valvular structure, the blood must be ultimately propelled towards the heart. The circulation is thus promoted, and many of the effects are produced which depend upon the rapid passage of the blood through the various organs; but it is brought about in a different way from what takes place in active exercise, where muscular motion is required. In the idea which we have given of the operation of the two kinds of exercise, we have considered each of them as being performed seperately; but it is evident that, in the way in which loco-motion is actually practised, both the kinds are generally combined, although in different proportions. In walking, which is the most complete kind of active exercise, pressure is necessarily made upon the veins, so as to bring about the mechanical propulsion of their contents; while, on the contrary, there is a certain quantity of muscular exertion in most kinds of gestation. The species of exercise which unites the two in the greatest degree, and which, at least in modern times, has been thought the most conducive to health, is riding on horseback. Here we have a considerable share of active exercise, together with the fullest operation of the passive effect on the venous part of the circulation, while, at the same time, we enjoy the benefit of fresh air, and all the other extraneous circumstances in the highest degree. We shall have occasion frequently to refer to the effects of exercise in treating of the cure of diseases, and we shall then notice some other species of gestation, as sailing, swinging, &c. which have been especially recommended for the removal of particular complaints.

The fifth class of those causes which act upon the system generally in the removal of diseases, are occupations and modes of life. Of the effect of these, both in inducing disease, and in removing it, no one can be ignorant; but their operation is obviously of a mixed kind, not depending upon any single agent, but upon the conjoined action of all those which we have already considered. In pursuing the various trades and professions, which occupy most individuals in a highly civilized state of society, the body is necessarily exposed to peculiarities of air, temperature, diet, and exercise, so that to any one or other of these heads we may perhaps attribute all the constitutional effect which is produced. Besides their general operation, there are certain specific or local actions, which would require to be noticed here, were it our object to treat particularly upon this topic. There are some manufactures in which the body is continually surrounded with peculiar exhalations: in others, the air is loaded with mechanical particles; in some, the individual is always exposed to a certain range of temperature; while, in others, the body, or certain parts of it, are constantly kept immersed in water or aqueous vapour. Some trades require the perpetual use of certain limbs only; some keep the body always in a particular posture; while there are others, which lead to the exercise of certain functions or faculties only, by which they are made more acute, at the same time that the remainder seem to be rendered proportionably torpid.

We have enumerated moral and physical habits among the agents which may be employed in the removal of disease; and there can be no doubt of the powerful influence which they possess over the state of the constitution. Considering the subject in the very general manner to which we are necessarily restricted, we may refer the effect of habit, in either inducing or removing disease, more particularly to the degree of regularity which is observed in performing the ordinary offices of life. It has been found, by ample experience, that the animal constitution, and more particularly that of man, is capable of being accommodated to a great variety of modes of life, which seem to be almost equally well adapted to it, but that it is easily deranged, and liable to suffer greatly, if the changes are too rapid. Although a medium temperature is more salutary than either extreme, yet the inhabitants, both of the frigid and torrid zone, are capable of executing their respective functions with sufficient regularity; but we should find that very serious evils would ensue to both of them, were we to transport them suddenly into the climates to which they had not been accustomed. There is nothing in which the influence of habit is more remarkable than in the diet; there are here, as in the former instance, certain things which we regard as the most salutary, certain articles naturally the best adapted to the digestive organs; but we have perpetual examples, where the stomach becomes habituated to substances, which, to one unused to them, would be absolutely incapable of being retained there, or from which it would be impossible for it to obtain any nutrition. It is unnecessary to illustrate this principle any farther, as the application of it to exercise, to clothing, and to sleep, are sufficiently well known; in all these points we perceive the operation of habit to be almost as powerful as that of original disposition, and in some cases to be able to counteract what may appear the strongest tendencies implanted in us by nature. The application of this principle to the removal of disease must frequently be an object of great importance to the practitioner; and cases sometimes occur in which we are able to produce more permanent effects by a change of habit, than by the action of any other remedies, which, however powerful, are more transient in their operation. But, at the same time that a change of habits becomes, in the hands of a skilful practitioner, an instrument of great efficacy, it must be borne in mind, on the contrary, that when either the mental or corporeal faculties are become habituated to a certain train of actions, these actions constitute, as it were, a part of their nature, and must always be attended to in our medical treatment. This is particularly necessary to be observed, both in the regulating of the diet, and in the administering of medicine, where the same substances that would be highly stimulating to one individual, would be inactive, or even comparatively sedative, to another. One of the objects, therefore, to which we should direct our inquiries is, to make ourselves acquainted, not only with the nature, disposition, and temperament of the patients, but with all their acquired habits, and to regulate our directions and practice very much by the information which we obtain on these points.

An important circumstance to be attended to in the general treatment of disease is the management of the clothing, both with respect to the quantity to be employed, and the materials of which it is composed. The effects of clothing are to be referred altogether to its power of regulating the temperature of the body; and this it does, either by retaining the caloric generated or evolved in the system, or by preventing the too powerful action of the external heat upon it. In the climate of the British Isles, we have also, in an especial manner, to guard against the variableness of the temperature, by which the health is much more frequently injured than by the excess either of heat or of cold; and in our choice of the materials for our clothing, we are also obliged to pay a particular regard to the quality which certain substances possess of keeping off the effects of moisture. The principal circumstance which we have to attend to, is the power of conducting heat which certain substances respectively possess, which is in fact almost the only circumstance that requires the care of the medical practitioner; and on this subject, we may refer our readers to the experiments of Rumford and others, related in the article Heat. In the torrid zone, the excessive effects of heat are what we have principally to guard against: and here our clothing must be selected upon a different principle; we must employ those articles, which, both from their texture and their colour, are the least fitted to retain the impression of the sun's rays, and which allow of the free perspiration from the surface of the body, while, at the same time, they do not admit of its being very suddenly checked. It has not unfrequently happened, that, in highly civilized countries, the influence of fashion and caprice, and sometimes the injudicious operation of erroneous hypotheses, have led to the adoption of a kind of clothing, which is by no means the best suited to the climate. The general substitution of cotton for woollen may be adduced as an example of the first, while the pernicious custom of permitting children to have a large part of their body uncovered, as it is said, for the purpose of hardening them, is an example of the second error of this description, which has prevailed very universally in England during the last thirty years.

No less powerful, perhaps, than any of the circumstances which we have already mentioned, is the effect of sleep upon the system in the removal of disease. As a deficiency of sleep is, at one time, the most powerful agent in causing a deranged state of the functions, and, at another time, one of its most characteristic symptoms; so the due regulation of it, and the knowledge of the means by which it may be induced, are among the most valuable acquisitions of the medical art. An account of those remedies which are especially directed to accomplish this end, have been enumerated under the article Materia Medica; while for a theory of sleep, for the causes which render it necessary to the animal economy, and the effects which it may be supposed to produce on the system at large, we must refer to the article Physiology.

The passions may also be regarded as among the most active circumstances in both producing and removing disease, although it is seldom that the practitioner is able to employ them in the exercise of his art. The theory of the passions, the mode in which they are excited, and the connexion which they bear to the other parts of the animal frame, belong chiefly to the science of metaphysics; while the consideration of their effects upon the physical constitution fall strictly within the province of the physician. When we come to inquire into the cause of individual diseases, we shall have frequent occasion to observe the influence of the passions upon them, how, in some cases, they may almost be regarded as the origin of certain morbid affections, while in others they seem to counteract the impressions derived from the sources of disease. It may be presumed, that the passions act, in the first instance, upon the nervous system; but through the medium of this we observe their effect to be exercised upon the heart and arteries, and upon the whole of the functions connected with them, so that there appears to be no circumstance in the human constitution which operates more extensively on all parts of the animal frame.

The last branch of Therapeutics, that which has been denominated Hygeine, still remains to be considered. It consists in the investigation of those circumstances which tend to the promotion or the preservation of the health, and is a subject of much importance, and of extensive interest: But after the remarks that we have made above, there is little to be added on this topic. It is obvious that, by a complete acquaintance with the causes of disease, we learn the most effectually to guard against them; and that it is by a due regulation of air, exercise, diet, and other circumstances which we have considered under the title of general remedies, that we are to produce such a vigorous state of the constitution, as renders the body the most capable of performing all its functions, and the least obnoxious to morbid actions of various kinds.

Part IV. NOSOLOGY.

The fourth of the great divisions into which we arranged the subject of medicine is Nosology, or that science which treats of the classification of diseases. The view which we have taken of Pathology naturally leads us to regard diseases as depending upon certain general principles, or common causes, in consequence of which they bear a more or less intimate relation to each other, although, at the same time, they exhibit specific differences, which entitle them to distinct appellations, and may require different modes of treatment. This conclusion is so obvious, that, in the description of diseases, it is impossible not to form some systematic classification of them, either depending upon their supposed primary cause, the resemblance of their symptoms, or the parts of the body which they affect. These attempts at arrangement were, however, in the first instance, rude and imperfect, proceeding upon false analogies, or upon very inadequate conceptions of the nature of the morbid actions, and generally comprising only a partial view of the subject.

The first author, who attempted a general arrangement of diseases upon professedly scientific principles, was Sauvages; and when we consider how much he accomplished, and compare his labours with the improvements that have been made by his successors, we must allow him great credit, both for the boldness of the attempt and the merit of the execution. He not only formed a systematic plan, in which were included all the diseases to which the body is incident, but he arranged them, according to the Linnæan method, into classes, orders, genera, and species; gave to each an appropriate appellation; and, in short, reduced into a well digested form what was previously a confused and chaotic mass. It was not, however, to be expected, that a first attempt of this kind should be incapable of farther improvement, especially when we consider the nature of the subject in question, consisting of a science, the fundamental positions of which are hypothetical, and include a great variety of topics, each of which has been found sufficient to exercise the talents of the most ingenious and learned men of the times, and still remains involved in obscurity. In considering the subject of Nosology, we shall first offer some observations upon the general principles on which an arrangement of diseases ought to be framed; we shall afterwards give an account of the most approved systems that have been proposed by various writers since the time of Sauvages; and shall conclude by offering our own ideas upon the subject.

CHAP. I.

General Principles of Nosology.

We need not enlarge upon the advantages to be derived from classification in the various departments of natural philosophy. By comparing objects with each other, we obtain a clear conception of their identity, and are thus enabled to give to each of them their appropriate appellation; and having ascertained their nomenclature, and the relation in which they stand to each other, we are better prepared for acquiring a knowledge of their intimate nature and properties. Two plans of proceeding have been adopted for the accomplishment of these objects, which are essentially different, and, to a certain extent, even opposite to each other. The first, and that which seems the most obvious process, consists in tracing out the resemblances between the objects of our research, in shewing their connexion with each other, and in developing the general principles to which their properties may be referred. In the other case, we attend almost exclusively to the points in which the objects to be compared differ from each other. We endeavour to lay down minute shades of distinction between them, and to detect some lines of demarcation which may separate what, to an inexperienced eye, appears the most closely united. To a certain degree, both these methods of proceeding are had recourse to in all scientific arrangements: in the formation of our large classes, we proceed only upon the plan of resemblance; while, in the subdivision of them into smaller groups, we necessarily pay more attention to the differences of the objects under consideration. But although this union of the two methods must, in some measure, always exist, we find that, from the peculiar genius of the author, the nature of his subject, or from other circumstances, there will be a preponderance to one or the other of them in all cases; and, according to the degree in which it prevails, the arrangement assumes an appropriate character, and is denominated either natural or artificial.

Each of these has its advantages: the natural method is obviously the most proper, when we wish to obtain a knowledge of the nature and qualities of the object under consideration; but where we are anxious to assign to each individual its specific name and place in the system, we must have recourse to an artificial arrangement. This last method has been very correctly compared to a dictionary, in which the words are placed in alphabetical order, without regard to any circumstance except the mere position of the letters; whereas the natural arrangement is analogous to a dictionary in which the words are placed according to their signification, their derivation, or some other principles connected with grammar or philology. The science of botany, which consists very much in nomenclature, and where a great part of our attention is occupied in the discrimination of a plant from those which the most nearly resemble it, an artificial method has been found essentially necessary; and we accordingly feel the superior utility of the system of Linnæus, notwithstanding all the improvements that have taken place since his time, and the laboured attempts that have been made to supersede it. Indeed it may be confidently affirmed, that the defect of his method consists, not in its departure from the natural relations of vegetables, but arises from the anxiety which the author felt to combine certain portions of a natural arrangement with one which, in its general aspect, is obviously and confessedly artificial. In the various departments of natural history, it is necessary for us to adopt a system in which every article may be included; but unless our knowledge of the science in question be absolutely complete, it is not possible to accomplish this, except by adopting a principle of classification, which depends upon some obvious circumstance, or trivial character, often little connected with the real nature of the subject.

With respect to the arrangement of diseases, we have no hesitation in asserting, that our object must be, to attempt a natural method of classification. What we wish to obtain is, not the name of the disease, but a knowledge of its cause; of the effect which this cause produces upon the functions of the individual; and of the means which must be had recourse to for the removal of the morbid condition. We ought to make ourselves intimately acquainted with every thing that regards the nature of the disease in question; but it is of comparatively little importance what class and order it occupies, in a methodical system, which must, in many cases at least, be formed, not upon the grand principles of pathology, which are obscure and uncertain, but is deduced from some symptom, probably of little moment, except as it affords an object for diagnosis. Besides, although there are some diseases of a specific and determinate nature, the general character of which, as well as their whole progress, may be distinctly described, in the greatest number of instances this is not the case. We frequently find, on the contrary, that the shades which divide health from disease, as well as those which separate diseases from each other, are faint and indeterminate; that it is more by the comparison of the previous circumstances, than by the present phenomena, that we are to form our conclusion; and that, whatever care we may bestow upon our definitions, we are often embarrassed by the occurrence of irregularities, which render our best directed attempts nugatory and inefficient.

When we form our descriptive characters in the different branches of natural history, we have an actual substance presented to us, which may be perceived by the senses, and becomes the immediate object of observation and experiment; but, with respect to diseases, we have merely an imaginary, or at least a supposititious, existence to contemplate, cognizable only by its effects, which are themselves indeterminate, and often very hypothetical. Before we can enter upon our arrangement, and establish our classes and orders, it is necessary to decide what is to be considered as constituting a disease. Are we to regard as such each individual symptom? or are there certain groups or combinations of them, which are always contemporary, and necessarily connected together, to which this denomination more properly belongs? Then, if we ascertain this point, and determine what combination of symptoms ought to be considered as forming a disease, we have still to enquire, what degree of deviation from them is necessary to change the appellation, and to convert one disease into another. We are also to enquire, how far, in this arrangement, we are to regard the causes, or whether we are simply to look at the effects; how far we are to take into account the power which the constitution or habits of different individuals exercise in modifying the phenomena, how far the circumstances in which the patient is placed, or even the mode of treatment to which he may have been subjected. These considerations, and others of an analogous nature, are sufficient to prove to us, that diseases are not possessed of that definite character, or even of that determinate existence, which can enable us to seize upon their essential features, for the purpose of scientific definition, and to place them in a regular systematic order, founded upon these characteristic differences.

And besides these circumstances, which are of a more general nature, and present insurmountable obstacles to the plan in its fundamental parts, we shall feel the individual difficulties to rise up at every step of our progress. Even if we succeed in establishing the definitions of individual diseases, we shall still have to decide what are to be considered as species, or what only as varieties; we shall then have to form specific characters, which may include all these varieties, and afterwards generic characters, to include the species, and so on until we arrive at the classes; a process which will be found extremely difficult to accomplish, if not absolutely impracticable. So far as the natural and artificial methods of classification proceed respectively upon the principle of tracing the resemblances, or of pointing out the differences between the objects of our enquiry, although, to a certain extent, both of them are to be made use of, yet much more practical advantage is to be obtained from the former than from the latter. By diligently investigating the phenomena of diseases, and observing the connexion which they bear to each other, we are often enabled to judge of their nature, and of the means which are necessary for their removal, although we may find it difficult to assign them a distinct appellation, or to reduce them to a proper genus and species.

In the various departments of natural history, we find an artificial arrangement peculiarly convenient, in consequence of the power which it gives us of including in our system every individual object connected with the science, a circumstance which is not necessary in medicine. Here one chief concern is, to obtain a knowledge of the nature and properties of the subject in question; and, except so far as it promotes this knowledge, we have little interest in becoming acquainted with its relation to other objects. It is no essential objection to a natural arrangement of diseases, that it must be imperfect, because each part may be regarded as, in some degree, independent of the rest; and any additional information that we from time to time acquire, may be added to our former stock of knowledge, and may be employed in completing the system, without necessarily affecting those parts of it which have been already established. But in giving our decided preference to a nosological arrangement, where the natural connexion of the parts is the grand point to which we direct our attention, we are not, on this account, to neglect those minuter circumstances, which may enable us to arrange particular sets of symptoms into separate groups, or to lay down specific differences between them, which may depend upon something, in itself of little importance, and only deserving of notice, as affording the means of discrimination. Those which have been termed diagnostic or pathognomonic symptoms, will be found of essential service in the formation of our genera and species, while, in forming our classes and orders, we are to depend almost exclusively upon the natural characters.

Having determined upon the kind of system which we propose to adopt, we are next to enquire in what way it is to be carried into effect; whether we are to proceed synthetically or analytically? are we to take separate parts or single phenomena, and connect them together into small divisions, which we may denominate species, then unite a number of species to form our genera, a number of genera to form our orders, and a number of orders to form our classes? Or, are we to proceed in the opposite direction, to establish our classes, in the first instance, upon the general principles of pathology, and to divide these into smaller and smaller portions, until we arrive at groups too minute to admit of farther subdivision? We apprehend, that the latter method is the one which will be found the most advantageous, as being that which is the best adapted to the construction of a natural system, which it is our object to establish. But here again, as in so many other cases, we must unite the two plans, and endeavour to obtain the benefits of both; while we adopt the analytical method, in forming our larger divisions, which must be derived from their natural characters, we may occasionally employ the synthetical plan in forming some of the smaller groups, and in laying down the minute and more artificial characters, which we shall find it convenient to have recourse to in this part of our system.

But, before we can make any advance in our classification of diseases, it is necessary to establish the correct meaning of the term disease, or rather to what combination of symptoms the term ought to be applied. Are we, for example, to call every distinct symptom a disease, or what number of them are we to combine together for this purpose? The question, although very important, is one to which we cannot return a general answer that will be universally applicable, but in each individual instance we must be guided by the particular circumstances of the case. Those circumstances which most especially direct us in our determination are, first, the uniform connexion of the symptoms; 2d, the facility with which they may be referred to some general operation, which is to be regarded as their immediate cause; 3d, the relation which subsists between them, as rendered apparent from the part of the body which they affect; 4th, the nature of the operation which they exercise upon the functions; and, lastly, the power which remedies seem to possess over them.

The first of these circumstances, although the mere result of observation, and frequently quite independent of theory, is of the most general application, and is the most invariable in its relations. We notice a certain train of phenomena, which are either contemporary or occur in immediate succession, presenting a series of events, which we should not have been able to predict, but which, when they have been observed for a sufficient length of time, we regard as necessarily connected together, and endeavour to refer to some general principle. A person, who had never before witnessed the cold stage of an intermittent, would have no conception of the subsequent stages of heat and perspiration; but after having repeatedly observed, that these steps succeed each other in regular order, that the cold is followed by the hot stage, and the hot stage by that of perspiration, he gradually acquires the idea of their being all of them part of one disease; and he concludes, that they depend upon one affection of the system, which causes them to occur in regular succession. This train of events we therefore consider as constituting one disease, to which we give a specific appellation; and we regard each of them separately as only symptoms, or indications of the presence of the disease, or as parts of it, which are necessary to its existence, and essentially connected together.

The next circumstance which we mentioned, as enabling us to combine separate symptoms, and to class them together as one disease, is their being easily referable to one common cause. When the action of the digestive organs is deranged, so that the stomach performs its office in an imperfect manner, a number of morbid affections are experienced, which may be obviously referred to this derangement. Yet the affections themselves vary in almost every case; they do not follow in any regular succession; and, so far as we can judge, merely from the manner of their occurrence, we might suppose them to be unconnected with each other.

The local situation or connexion of symptoms, or their appearing all to originate from one part of the body, is a circumstance which we attend to in our combination of them into separate diseases. Owing to the communication which exists between the various parts of the animal frame, as influencing its powers and functions, it not unfrequently happens that affections, apparently of a very different kind, all proceed from one source; and when, either from our sensations, or from any other cause, we are led to conclude this to be the case, however dissimilar they may otherwise appear, we regard them as having a common origin, and as constituting one disease. This principle sometimes affords us a useful indication in affections of the internal viscera, which are obscure in their commencement; and even when far advanced, the symptoms are often anomalous in their nature, and not easily reduced to any common cause; yet, if they seem to proceed from the deranged state of any one organ, we do not hesitate to pronounce them as all forming one disease, although consisting of many morbid actions.

We are also guided in our classification of symptoms by the nature of their operation upon the different functions or powers of the system. Even although they should manifest themselves in various parts of the body under very different forms, and without any regular order of succession, yet we are led to regard them as originating from a common cause, and constituting one disease, if we perceive that they affect the same class of organs, and reduce them to the same morbid condition. This mode of reasoning is particularly employed in scrofula, the symptoms of which are almost infinitely varied; but if we regard it as being essentially an affection of the absorbent vessels and glands, we consider the symptoms as forming part of the same disease, however diversified they may be in their seat and external character, as long as we conceive them to originate in this set of organs.

And, in the last place, there are certain cases, although less numerous, where it is thought a sufficient bond of union between the symptoms, that they are all affected in the same way by the action of remedies. This has been generally considered as our surest guide in judging of the multifarious and variable phenomena which are presented by syphilis: there is scarcely a part of the body which is exempt from its attack, or a function that does not occasionally experience its influence; and it must of course assume a variety of appearances, that baffle our most laboured attempts at generalization; yet, for the most part, we consider ourselves warranted in deciding upon the presence or absence of the disease, by ascertaining what is the effect of mercury upon it. The same mode of reasoning, although in a less certain degree, is applied in some other constitutional affections, and is occasionally a useful assistance in our arrangement of symptoms; but it must be acknowledged, that it is very liable to misconception or mistake, and is the least certain of all the methods of proceeding that have been enumerated.

By a judicious application of the above principles, we are generally able to combine individual symptoms into those groups or assemblages, which we call diseases; but a new difficulty here occurs,—that the same group is, in some instances, a distinct disease, while in others it becomes itself a part only of some other disease, and is then to be considered as constituting merely a symptom of a more extensive affection. Fever, which so frequently occurs as a primary effect of various noxious causes, and which extends its action over almost every organ and every function of the body, is sometimes only symptomatic of other diseases; paralysis, in like manner, is sometimes no more than a single effect, which, in combination with others, becomes the indication of a farther derangement of the system; and the diseases of the nutritive organs are found to be, at one time, symptomatic of various febrile complaints, while, in other cases, they are primary affections, and exist without the intervention of a previous morbid condition of any of the functions.

And besides the facts of this description, which are chiefly interesting as showing the connexion which subsists between the various functions of the body and the parts of which it is composed, we not unfrequently find it difficult to decide, whether certain symptoms are primary or secondary, from the circumstance of their occurring in strict connexion with symptoms, obviously forming a part of a more general disease, and sometimes, as far as we can judge, being quite independent of them, or entirely idiopathic. A pain of the side is, at one time, the most clear indication of an inflammation of some of the contiguous viscera, while, in other instances, we cannot trace it to any more remote cause, or refer it to a more complicated disease. A disorder of the stomach is a frequent effect of a derangement of the function of digestion, and it is unnecessary to search for any other origin; but we are well aware that, in certain instances, a pain of this viscus, and a deficiency of its powers, are no more than a symptom of some other general affection, and can only be effectually relieved by removing the constitutional disease.

The above remarks will render it evident, that, from the very nature of different diseases, some are essentially more definite in their symptoms, and exhibit a more regular series of phenomena, while there are others which are more indecisive in their character, which run into each other by insensible gradations, and are distinguished by almost imperceptible shades from the state of perfect health. The small-pox may be adduced as an example of a definite combination of symptoms, which, however slight in its attack, must always have an actual existence; but a weakness of the stomach, a torpid state of the bowels, or a langour of the nervous energy, may occur, and yet may scarcely amount to what we denominate a disease. These are merely comparative states, in which health and disease are little more than greater or less degrees of the same thing; and become morbid, rather by a reference to a standard condition of the individual, than from the occurrence of any positive phenomena.

It not unfrequently happens, in the classification of diseases, that we find the natural charactars to be in direct opposition to each other, according to the aspect in which we view them; so that, after having established certain symptoms as constituting a well-marked species, we meet with varieties which are clearly referable to the same species, which, however, differ very essentially from each other in many of their most important relations. The example of the small-pox, which we adduced as one of the best defined diseases with which we are acquainted, may serve to illustrate this position. It consists of a train of symptoms, constant and uniform in their operation, and which succeed each other in a regular progress; yet the disease is capable of existing under two forms, which differ from each other in the general state of the system, where the individual symptoms are remarkably varied, and where a different kind of treatment is required. No one will, however, hesitate to class the most mild case of distinct small-pox as being the same disease with the most acute confluent case, although the symptoms and treatment differ so considerably from each other. But here we are guided in our judgment by the circumstance of the two sets of symptoms being both referable to the same exciting cause; and where this can be clearly ascertained, it is always regarded as superseding every other consideration. Where the exciting cause is obvious, and generally recognized, we have indeed little difficulty in our proceeding; but there are many cases in which it becomes a point of extreme difficulty, and where we can only decide by a very extensive observation of the phenomena, and a careful induction of every circumstance connected with the origin and progress of the disease. The nature of what has been called the yellow fever of America and the West Indies is a question of a very interesting nature, both with respect to theory and practice: whether it be a specifically distinct fever, proceeding from a peculiar contagion; whether it be a variety of the typhus of this country; or whether we are to regard it as an intermittent, modified by climate, and the peculiar temperament of the inhabitants.

In determining what diseases are to be regarded as varieties of the same species, we are guided by various circumstances. When we have it in our power clearly to ascertain the exciting cause, this alone is deemed sufficient for our purpose; but, except in the case of specific contagions, we can seldom have recourse to this method of judging. In other instances, we take into account the probable origin of the disease—the resemblance of its symptoms—its seat—its general effects upon the functions—and the operation of remedies upon it; but, after all, we are often unable to ascertain the relation which diseases bear to each other, and are obliged to regulate our treatment merely by the individual symptoms as they present themselves to our notice.

There are other circumstances which will afford considerable obstacles to our attempts at the classification of diseases, depending upon the conversion of one disease into another—the union of two or more diseases together—the change that is effected in the nature of diseases, by the remedies that are employed in their commencement—and a variety of extraneous causes, which are essentially connected with the subject, and must, at all times, render the arrangements of nosology less perfect than those in the various departments of natural history. In this science it is the general plan to form a regular series of classes, orders, genera, and species; each class including all the orders that are placed under it, each order including all its genera, and each genus all its species: but this regular scale cannot be uniformly adhered to in the classification of diseases. We have not those general characters, applicable to a great variety of cases, which enable us to compose the larger groups; nor, on the contrary, are we able to detect those minute circumstances which give the specific characters, and enable us to form the smaller divisions that are capable of being connected together into the genera, orders, and classes. After having laid down the characters of our classes, we find ourselves much embarrassed in determining upon the principle on which we ought to proceed in dividing them into orders; and we sometimes find certain circumstances, which appear to denote the generic character with sufficient accuracy, where we can perceive no point of resemblance, which will serve to unite these genera into orders; or we may find them to be contradictory to each other. These difficulties are, in part, the necessary result of all attempts at forming a natural arrangement of any description, and partly upon the indeterminate nature of disease, and upon the uncertainty which is essentially attached to every branch of the subject.

From all these considerations, both those which apply to the formation of natural arrangements in general, and those which attach to nosology in particular, we may conclude, that any system which we can form must be imperfect and incomplete; that we cannot construct a regular gradation of classes, orders, genera, and species; and that there will be some diseases which we shall be unable to refer to their proper situation, and which must, for the present, remain unarranged.

It is asserted by Cullen, in his remarks on nosology, (*Synopsis*, t. ii. p. 11) that species are the only natural divisions, and that genera, orders, and classes, are artificial arrangements, to be regarded merely as assisting the memory, or serving some other secondary purpose. But he seems to have habitually violated this principle in his system; for it is the *genus* to which he applies his standard definition, and which, in most cases, constitutes the actual disease to which his remarks are referred; so that he ought either to have made that into the *species* which he has denominated the *genus*, or to have considered the *genus*, as he lays it down, to be the natural disease. In the case of small-pox, which, as being of a well-marked nature, we have already instanced, after having formed a class and an order, under the order he places the genus variola, which conveys the proper definite idea of the small-pox, and cannot, therefore, be regarded as an artificial classification of symptoms, but the actual form in which the disease generally subsists, as produced by a specific contagion, which is always its immediate exciting cause. Under the genus variola he places the two species, discreta and confluens; but these we conceive should rather be considered as varieties, because the same contagion produces the one or the other of them, according to individual peculiarities of constitution, particular states of the atmosphere, or other extraneous and incidental circumstances.

Sauvages, in the formation of his methodical classification, proposed to follow the plan which Linnæus had so successfully pursued in botany, and to establish the five successive gradations of classes, orders, genera, species, and varieties, (*Nosol. Meth; Proleg.* sect. 25, *et seq*); and in this he has generally been followed by succeeding nosologists; yet we suspect they have been misled by a false analogy. There is obviously nothing in the number five, that should cause us to adopt it, except there be that number of circumstances proper for classing the objects, and which apply successively to the different divisions, as we advance in the system. It would appear, that in botany this number has been found the most convenient; and that by referring to the stamens, pistils, seed-vessels, &c. we arrive, by successive steps, at what is called a species, which constitutes the plant, as it was originally created from the seed; while the variety consists of those different forms which are produced from the same seeds, and which, on this account, we regard as accidental, and depend on the incidents of soil, climate, &c. acting upon the same plant, and changing its external appearance. (Linnæus, *Phil. Bot.* sect. 157-8.) But, in diseases, there are no precise circumstances of this kind which mark the successive steps, on which we can erect our gradations of arrangement; the only point that we have to guide us, is the greater or less degree of resemblance; and there does not appear to be any reason why we should originally adopt the number five in preference to any other number, or why we should think it necessary to employ the same number in the different parts of one system. Our plan must be, to associate those groups of symptoms which may be considered as constituting the complete disease in its fully formed state, but which are independent of the peculiarities that attach to individual cases, which proceed from certain states of the air, variations in temperature, and other extraneous circumstances. To this primary division, we think the title of species attaches with most propriety, both as expressive of the common origin of the disease, and as most analogous to the use that is made of the term in botany.

Having thus formed our species, we shall, in some cases, perceive well-marked characters that connect two or more species together, and with these we may constitute a genus. To refer to the former example: it is a characteristic feature of variola to commence with fever, at a particular period of which an eruption appears, which is also of a determinate duration; this may constitute a generic character, and will lay the foundation for a division, in which we may place Rubeola, Varicella, Vaccinia, and Scarlatina. Thus far we proceed synthetically, and at the same time upon natural principles, although, in the definition of our genus and species, we shall probably be obliged to have recourse, in a great measure, to artificial characters, in order to give a clear description of the respective stages. In this instance, we may perhaps proceed one step farther in the same direction, and establish a still more extensive division, which, according to the usual nomenclature, we may style an order, consisting of fever generally, without any reference to the existence of an eruption; but it will be found that there are very few instances in which we can proceed through so many successive steps, with even an appearance of regular systematic arrangement

Before we can form a classification of diseases, it will be necessary for us to obtain an accurate knowledge of the species; a knowledge which, in fact, embraces what is the most important in the science of medicine, and is the foundation upon which we must erect all our future information. But after we have well-digested this part of the subject, have carefully studied the relation of the symptoms to each other, and have formed them into those groups which constitute diseases, we shall generally find it most convenient to proceed analytically, to have recourse to our pathological principles, and to consider what are the morbid conditions to which the different functions of the human body are liable. Having carefully ascertained these conditions, we derive from them the natural classes; these classes may be more or less subdivided, until we arrive at the species, the smaller divisions which had been formed at the lower end of the scale. But the number of gradations through which we are to pass is quite uncertain, and will vary in the different cases; sometimes a primary class may not admit of more than one subdivision, while there are others which may be divided successively three, four, or a greater number of times, before we arrive at the ultimate or smallest groups. There may even be some instances in which we have a well-established class, which cannot be divided into any smaller portions; while, on the contrary, there are species which it will be impossible to connect together into larger masses. The names which we apply to all these gradations, whether classes, orders, genera, or species, must be altogether arbitrary, and of little importance, because there is not the same correspondence between the different parts of the system as in botany and in many parts of natural history. It may perhaps be desirable not o use these terms in medicine; or if that should be thought too great an innovation, the most simple plan will be to call the large divisions *classes*, and the smallest of those which constitute a distinct disease *species;* we may apply the term *variety* to the accidental changes in species by extraneous circumstances, and insert *orders* and *genera*, as we find them most convenient, in the subdivision of the classes.

It has been made a subject of discussion among nosologists, whether it be proper to employ negative characters in the definition of diseases. It must be acknowledged that they are less important than positive ones, and it may be said that they do not add to our real knowledge of the nature of the subject in question; but no one can have paid much attention to the actual detail of scientific arrangement, without finding it, on many occasions, of great practical utility in the discrimination of two objects that bear a general resemblance, to point out the qualities that are not possessed by one, but which are found in those that are contrasted with it. By a rigid rejection of all negative characters, we should, in many instances, be obliged either to employ a long and tedious circumlocution, or perhaps entirely to omit a circumstance of considerable importance.

The nomenclature of nosology is a subject that must be attended to, and which may materially promote or retard the progress of medical knowledge. The great object is, after having clearly established a correct conception of the disease, to give it an appropriate name.[*] But here different considerations present themselves: The same disease may have been described by different authors, and may have obtained from each of them a different appellation, or it may have received one which is palpably erroneous, founded on some false theory or some incorrect observation; a name may have been given, which, although not palpably erroneous, is better adapted to some other disease; or a name exactly suited to the disease in question may have been applied to some other disease, to which it is less appropriate. These objections, and some others of a similar kind, depend upon scientific principles, and there are objections of a different nature, which are not to be disregarded, that may be considered as strictly philological. Such are a Latin word with a Greek termination, a word obviously derived from the Greek, but not spelled conformably, or a name composed of two words, which do not bear to each other a correct grammatical relation. With respect to both these kinds of erroneous nomenclature, it is more easy to point out the defect than to substitute what is perfect in its place. Many names, which are obviously objectionable, are so established by long custom, and rest upon such high authority, that it seems scarcely possible to alter them; we shall find writers of equal respectability applying different names to the same disease, and calling different diseases by the same name. In short, we must either attempt an entire innovation, which, in the present state of our knowledge, would be perhaps premature, and should not be attempted, except by one fully competent to the task; or we must rest satisfied with correcting a few of the grosser errors, and leave the labours of a more complete reformation to be accomplished by our successors.

The same general principle may be applied to the philological part of the nomenclature. When a term, however unclassical, has been sanctioned by long use and respectable authority, we shall tolerate it; and we shall never introduce a new term, unless there be none already in use which will correctly convey our ideas; or when it is conceived that the one usually employed may lead to some misconception respecting the nature of the disease, or the relation which it bears to other morbid conditions of the system. Many judicious observations on nosological nomenclature occur in Dr. Young's *Medical Literature*, (p. 31, *et seq.;*) and although we shall not follow his example, in attempting so great a revolution, we shall frequently avail ourselves of his suggestions.

CHAP. II.

Remarks on Different Systems of Nosology.

We must now examine the principal systems of Nosology that have been offered to the public, beginning with that of Sauvages, who, as we stated above, made the first attempt to arrange diseases, upon a scientific plan, into classes, orders, genera, and species. The first outline of his method appeared in the year 1731, but it received various additions and alterations before its republication in 1763. *Eloge* par M. De Ratte.

He makes 10 primary divisions or classes; 1. Vitia, a very miscellaneous collection, consisting of mere local diseases, of various structural affections, of cutaneous eruptions, of mechanical injuries, and of the effects of external violence. 2. Febres, consisting nearly of the same diseases to which the term has been applied by later writers. 3. Phlegmasiæ, including the exanthemata along with the various inflammatory fevers. 4. Spasmi, consisting of irregular action of the muscles, both voluntary and involuntary. 5. Anhelationes, diseases depending upon an irregular action of the muscles that are concerned in the function of respiration, an anomalous and unnecessary class. 6. Debilitates, consisting of defective action of the organs of sense and motion, an ill-defined class, as depending sometimes upon a mechanical obstruction in the part, and sometimes upon a mere derangement of its functions. 7. Dolores, expressive of pains of various kinds, a class which is very miscellaneous and indefinite. 8. Vesaniæ, consisting of mental affections. 9. Fluxes, diseases which consist in a morbid condition of the fluids that are discharged from the body, either with respect to quantity or quality. And, *lastly*, Cachexiæ, diseases which consist of a general bad habit of the body, a class, from its nature, not well defined, and comprising many affections that have little connexion with each other.

We have already expressed our opinion of the merit of this system, which we conceive to be very considerable; for, independent of its being the first attempt of the kind, we shall perceive that many of the subsequent arrangements that have been made are little more than corrections or alterations of Sauvages' original plan. His great error is the unnecessarily multiplying of diseases, for by this means we destroy a great part of the benefit that arises from a systematic classification. He has formed 315 genera, but as he has proceeded upon the plan of considering every deviation from health, however slight, as deserving of notice, if we strike out those that are of little importance, we shall not perhaps find the number much too great: his species, on the contrary, are most unreasonably extended to the number of about 2400; and he has admitted as a ground for division every diversity of symptoms or of causes, however slight or unimportant. Although his primary divisions are not in all cases sufficiently distinguished by natural characters, yet they are most of them tolerably well marked by some obvious symptoms, and we may doubt whether the attempts that have been made to reduce the number of the classes has been productive of any real advantage. His generic definitions possess considerable merit; they are, for the most part, perspicuous, and sufficiently explicit; and although their subdivision into species is much too minute, yet it often displays great professional science, and an intimate acquaintance with the phenomena of disease.

The next attempt to form a nosological system was made by the celebrated Linnæus. The great ingenuity which he displayed, in his arrangement of the various departments of natural history, does not appear to have been exercised with its usual success on the subject of diseases, a circumstance which appears, in a great measure, owing to his not possessing a sufficient degree of professional knowledge, and also to his habit of forming his classifications principally upon artificial characters. He arranges all diseases into the four primary divisions of Febriles, Temperati, Fluidi secretionis, and Solidi; these he afterwards subdivides into eleven classes. Under the denomination of febrile diseases are contained the three classes of Exanthematici, Critici, and Phlogistici; the first coinciding with the usual meaning of the term; the second being restricted to the fevers that are attended with a critical deposition from the urine; and the last comprehending the inflammatory fevers of various kinds. In the second great division are the classes of the Dolorosi, an ill-assorted assemblage of diseases, principally symptomatic; the Mentales, or mental affections; the Quietales, or those attended with a defect of vital action; and the Motorii, or those diseases which consist in an increase or irregularity of the muscular power. The third division, the Morbi fluidi secretionis, consists of two classes, the Suppressorii and the Evacuatorii; and the diseases of the solids also of two, Deformes and Vitia. Upon the whole, we think the method of Linnæus is less valuable than that of Sauvages; the characters of the great divisions are less natural, and in the reduction of them into genera and species, although, perhaps, there is more of technical skill, we meet with less correct pathology; while the definitions are founded upon trivial circumstances, and derived from false analogies.

The systems of Vogel and Sagar, the former of which was published about the same time with that of Linnæus,* and the latter a few years subsequently to it †, do not differ very essentially, in their general aspect, from that of Sauvages. Vogel has 11 classes; Febres, Profluvia, Epischeses, Dolores, Spasmi, Adynamiæ, Hyperæstheses, Cachexiæ, Paranoiæ, Vitia, and Deformitates. Perhaps this arrangement of classes may possess some advantages over that of Sauvages; but, in the formation of his genera, we think him decidedly inferior. He lays down no less than 560 diseases, to which he gives distinct definitions; and, in order to swell out this numerous list, he not only introduces many trifling and insignificant affections, but makes a number of trivial distinctions, which have no real foundation even as varieties. In proof of this allegation, we shall give an account of his first class of Febres. This is divided into the intermittent and the continued: of the intermittents there are 14 different kinds enumerated, and of the continued no less than 56. It is not a little curious to observe the fondness for minute division which pervades the works of the learned physicians, particularly among the Germans, who flourished about the middle of the last century. Continued fevers are divided into simple, compound, inflammatory, and symptomatic. The simple fevers are 20 in number; Quotidiana continua, Synochus, Amatoria, Phrenitis, Epiala, Causos, Elodes, Lethargus, Typhomania, Leipyria, Phricodes, Lyngodes, Assodes, Cholerica, Syncopalis, Hydrophobia, Oscitans, Ictericodes, Pestilentialis, and Siriasis. We need go no farther with Vogel's system, to prove that it is completely technical and artificial, and that it exhibits few of those broad characteristic features which are chiefly valuable in nosology; while, at the same time, it abounds in frivolous distinctions, which can only serve to oppress the memory, and can throw no light either upon the the nature or treatment of the disease.

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* Published at Gottingen in 1764

† Published at Vienna in 1771, and afterwards in 1776.

Sagar's classes are 13 in number, and are not very dissimilar to those of Sauvages. They are, Vitia, Plagæ, Cachexiæ, Dolores, Fluxus, Suppressiones, Spasmi, Anhelationes, Debilitates, Exanthemata, Phlegmasiæ, Febres, and Vesaniæ. His genera are 350, and are, for the most part, well defined, although sometimes the definition is so long as to approach to a history, rather than to constitute a mere character. To take an example of his method from the febrile diseases, which, as we have just seen, form three of his classes. The first of them, the Exanthemata is divided into the diseases that are contagious, and those that are not so. His Phlegmatiæ are arranged into three orders, Musculosæ, Membranaceæ, and Parenchymatosæ; an arrangement which is perhaps not always strictly tenable, but one for which there is some foundation in nature; while the Febres are divided into continued, remittent, and intermittent. The whole number of genera in the three classes is 38. Upon the whole, we consider Sagar's system as superior to Linnæus's or Vogel's, and perhaps, in some respects, an improvement upon that of Sauvages.

Cullen's Nosology appeared, in its original form, before that of Sagar*, but we have placed it after Sagar's, in our review of the successive improvements which the science experienced; because, although we may trace in it a strong resemblance to the system of Sauvages, it differs from it more essentially than any of the other classifications. The genius of Cullen led him, on all occasions, to study simplicity; and he had a mind superior to all the details of trifling arrangement, of which we have seen the excessive degree in Vogel. Cullen's classes are only four, Pyrexiæ, Neuroses, Cachexiæ, and Locales. The two first are natural classes, embracing the diseases of the two systems of the blood-vessels and the nerves; and one great merit of his plan consists in his having brought together, under one head, the affections of the nervous system, which, before his time, had either been divided into several classes, or had been scattered in different parts, without any regard to their natural connection with each other. The third class of the Cachexiæ is much less definite; it scarcely contains any single natural character, and very few artificial ones, which can unite the individuals of which it is composed. But a still greater defect in his method is the fourth class, the Locales, which is altogether an heterogeneous assemblage, the principle of which is not a proper ground of classification, and, even if it were so, is violated in the most direct manner in numerous instances. There are many diseases that are strictly local in the three first classes, and as many that are not so in the fourth; and, even in the two first classes, there are some striking inconsistencies. The hæmorrhagies, which form an order of the Pyrexiæ, are not essentially febrile diseases; and, with respect to the Neuroses, it is only by the most strained and unnatural combination that Dyspepsia, Diarrhœa, and Diabetes, can be regarded as nervous diseases. The small number of classes, which probably Cullen conceived to be a peculiar excellence of his system, is in fact a great defect, and may be considered as the cause of many of its inconsistencies and irregularities; for it has not only rendered the classes themselves incorrect, but it has led to much unnatural and inappropriate arrangement of the orders. His great merit consists in the formation of his genera. Of these he makes no more than 151; and he defines them with a degree of perspicuity, elegance, and judicious discrimination, which far exceeds what had been done by his predecessors. With a few additions, the genera of Cullen may be retained nearly in the condition in which he left them; and the principal object that remains to future nosologists, is to arrange them into a more natural series of orders and classes.

On account of the general resemblance which all the above nosological systems bear to that of Sauvages, we have infringed a little upon the chronological order, and have omitted to notice in its proper place the *Synopsis* of Lieutaud, which was published prior to the Nosologies either of Sagar or of Cullen. Lieutaud's work can indeed scarcely be regarded as a nosological system; for it is a fundamental principle of the author to avoid systems of all kinds, and merely to arrange diseases according to some obvious external character, which should involve no speculative principle, and which can admit of no uncertainty. There is some plausibility in this plan of proceeding, but when we come to examine the results which it produces, even in the most able hands, we shall not be disposed to recommend it as a model for our imitation.

Lieutaud does not employ the usual method of classes, orders, and species; he divides his account of diseases into three parts or books, and these into eleven sections. The three great divisions are internal diseases, external diseases, and diseases of females and children. The internal diseases are divided into four sections; those which are general, or have no determinate seat, the internal diseases of the head, those of the chest, and those of the abdomen. The external diseases are, in like manner, divided into four classes; general diseases, those of the head, those of the trunk and limbs, and those of the skin. The second book contains the two sections of diseases of females and those of children. Not to insist upon a number of minor objections, which attach to the detail of this plan, it is at first view obvious, that it is fundamentally erroneous, in as much as the same diseases, at different periods, or under different circumstances, may belong to different parts of it. Thus a typhus fever, in its successive stages, may be placed in different sections: its commencement is sometimes merely a pain in the head, which is a disease of the second class; as it advances, it becomes a more general affection, and it must then be tranferred to the first section, while probably, in the latter stages, it is converted into a complaint of the stomach and bowels, and will then belong to the fourth section. We shall find, in fact, that this kind of conversion of symptoms takes place in a great majority of diseases. And with respect to the great division of internal and external, and general and local diseases, although to a superficial observer these may appear very obvious marks of distinction, yet in reality nothing can be more difficult than to apply this mode of arrangement. To a great number of diseases, each character may be assigned with almost equal propriety; there is a still greater number which change their nature during their progress, at one time being local, and at another being strictly entitled to the appellation of general diseases.

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* Cullen's first edition was published in 1767; the last which appeared under his own inspection was in 1785. M'Bride's sketch was published in 1772.

We shall probably be still more convinced of the insufficiency of Lieutaud's plan, by examining what affections are actually placed under the same section, and by considering what possible advantage can be obtained from such an arrangement, either with respect to a knowledge of the nature of diseases, or the mode of treating them. In the first section we begin with fevers, of which different species are enumerated; then comes the following list: Plethora, Vitium exolutio, Sanguinis inopia, Fluxium et eruptionum retrocessus, Dolores, Insultus catarrhales, Cachexia, Scorbutus, Lues venerea. Scrophula, Arthritis, Rheumatismus, Hypochondriasis, Hydrops, Stagnatio sanguinis et puris. Infarctus et Schirrhus, Tumores, Phlogosis, Purulentia, Grangræna, Insecta et corpora extranea, Venena. Now upon this list we shall briefly remark, that several of the diseases enumerated in it are neither internal nor general, nor have they an indeterminate seat, but, on the contrary, are external, local, and confined to a particular part, or to a specific structure. Equal, or even greater inconsistency, appears in his second division: Upon what principle can atrophia, aneurisma, and Hydrothorax, or cephalgia and angina, be considered as external diseases? In short, we shall find perpetual incongruities and contradictions in this method of arrangement; and we conclude, that however plausible it may appear in theory, it will be found impossible to accomplish it with any tolerable degree of success.

The next attempt at nosological arrangement which we must notice, is that of Darwin. Hitherto all the systems that had been proposed were to a certain degree artificial, depending upon circumstances that had only a remote connection with practice, and, in many instances, but little with pathology, or the general principles of the animal economy. Darwin, however, peofesses to proceed in a different manner: he pays little regard to external characters, to anatomical structure, or to the analogy of functions; but he founds his method entirely upon the operations of the system as a vital agent, or upon the supposed properties of the *spirit of animation*, that peculiar power or quality, which is inherent in the body, and essentially distinguishes it from all kinds of inanimate matter. The primary operations of this agent are assumed to be irritation, sensation, volition, and association; and these accordingly form the titles of his four great classes of diseases. These are subdivided into orders, genera, and species, chiefly in consequence of their respective excess or defect, their connexion with each other, or their specific relation to certain corporeal functions, and in this manner a nosological system is formed, which is elaborated with great care, and seems to have been the result of extensive professional knowledge and profound reflection. The effect, however, did not correspond with the expectations of the author: we have already had occasion to make some remarks upon his pathology, and upon the general character of his Zoonomia, from which it appears that he has proceeded in most cases upon a basis of theory which is not supported by facts; that he had a metaphysical turn of mind, which led him to prefer abstruse and refined speculations to physical researches, while he entangled himself in an intricate and mysterious train of reasoning, which perhaps no one has ever been able fully to develop.

And besides these general objections, which attach to the whole system, and the principles on which it is founded, there are considerable defects in the execution. He has regarded every separate symptom as a disease, and has thus made no distinction between primary and secondary affections: and, in short, with every appearance of method and arrangement, he confounds together, genera, species, and varieties. Then he has introduced into his system many circumstances, which can in no respect be regarded as diseases, but which are merely natural actions of the animal economy, that have nothing in their nature of a morbid tendency; and we think it may be asserted, that in not a few cases he has introduced diseases that have no real existence, obviously for the purpose of filling up or completing his system. As an example of what we have here stated, we shall quote, from near the commencement of the work, the second genus of the first order of the first class, the diseases of irritation, with increased action of the secerning system. They are as follows: Calor febrilis, Rubor febrilis, Sudor calidus, Sudor febrilis, Sudor a labore, Sudor ab igne, Sudor a medicamentis, Urina uberior colorata, Diarrhea calida, Diarrhea febrilis, Diarrhea crapulosa, Diarrhea infantum, Salivatio calida, Catarrhus calidus, Expectoratio calida, Euxdatio per aures, Gonorrhœa calida, Fluor albus calidus, Hæmorrhois calida, Serum a vesicatorio, Perspiratio fœtida, Crines novi. We shall take another example from the third class, the diseases of volition, in which the second genus of the first order are the increased actions of the organs of sense. The following is the singular list of these diseases: Mania mutabilis, Studium inane, Vigilia, Erotomania, Amor sui, Nostalgia, Spes religiosa, Superbia stemmatis, Ambitio, Mœror, Tædium vitæ, Desiderium pulchritudinis, Paupertatis tumor, Lethi timor, Orci timor, Satyriasis, Ira, Rabies, Citta, Cacositia, Syphilis imaginaria, Psora imaginaria, Tabes imaginaria, Sympathia aliena, Educatio heroica. These examples will probably be thought sufficient to prove, that although from an attentive study of the Zoonomia we may derive some new and valuable ideas respecting the actions of the animal economy; yet that, as a system of nosology, which is to afford us any information respecting the actual relations of diseases, or to direct us in the treatment of them, it is entirely useless and inappropriate.

The next arrangement that we shall notice is that of M. Pinel. This system, although reverting more to the method of Sauvages, in deriving the primary divisions from the functions of different parts of the body, or different sets of organs, aims at establishing a more natural arrangement than any which had preceded it upon this plan. He has five classes; Fevers, Inflammations. Hæmorrhages, Nervous diseases, and Lymphatic diseases. The fevers are arranged partly according to the nature of the symptoms, and partly according to the organs which are conceived to be primarily affected, into the six orders of inflammatory, bilious, putrid, malignant, and pestilential; and these are again subdivided into 15 genera. The genera are taken from the supposed characteristics which certain forms of fever assume, either as especially affecting particular structures, or consisting of the combinations of the leading symptoms of the orders; but the arrangement appears to us fanciful, and rather deduced from a preconceived speculation, than from the actual phenomena of disease.

The orders of the inflammations are taken from the structures which they affect; mucous membranes, diaphanous membranes, cellular texture, muscles, and skin. The first order, as its name imports, contains catarrhal affections of all kinds, as well as the mucous discharges from the intestines, the bladder, and the uterus. The two next orders consist of the inflammations of the different thoracic and abdominal viscera; the fourth, of the rheumatic affections; and the last, of the Exanthemata, the cutaneous eruptions necessarily connected with fever. There is certainly merit in this part of Pinel's system, although we think it would have been better to unite the fevers and the inflammations into one class; but, if these are to be separated, there is the same reason for making a distinct class of the Exanthemata. We approve of the plan of removing the hæmorrhages from the fevers. The nervous diseases are divided into four orders; mental derangements, unattended with fever, spasms, local nervous affections, and comatose affections. There may be objections to some parts of this arrangement; but, upon the whole, this class is considerably more perfect and natural than the corresponding one of Cullen.

The introduction of a class of lymphatic diseases is a decisive improvement in the system of Pinel, as it affords a natural and important object of classification, which is much better defined than Cullen's Cachexiæ, to which it must be regarded as, in a great measure, analogous. It is divided into cutaneous diseases and the diseases of the lymphatic glands; two sets of affections that are sufficiently distinct from each other, and it may fairly be questioned how far the first of them belongs to the place that it occupies in the system. To his five regular classes the author has wisely added an appendix of those diseases which do not admit of classification; a list which might be extended with advantage. Upon the whole, we think that Pinel's nosology combines more of a natural method, with an actual relation to the functions and structure of the body, than any which has preceded it; and that, although it is very far from being perfect, yet that he may be considered as having made a real progress in the science. The most defective part is the designation of the genera and species, in which, both with respect to accurate discrimination, and to the elegance and perspicuity of the definitions, he must be considered as very inferior to Cullen. His arrangement of the different kinds of fever, as has been already remarked, we conceive, is in many parts without foundation, although it is not improbable that it may have been the result of much study and reflection, and that M. Pinel may have supposed it one of his most successful attempts at classification. It is also to be observed, that the system, notwithstanding its appendix, is not complete; several very important diseases being omitted, or mentioned only in an incidental manner.

A system of nosological arrangement, in many respects differing from those that had preceded it, was attempted by Dr. Parr, of which we must now give some account. The object of this author was, to arrange diseases in natural groups or families, which might be so distributed as to exhibit a relation to, or connexion with each other, analogous to a natural system in botany. He has no classes, but arranges diseases into 12 orders, under the following names; Pyrexiæ, Phlegmasiæ, Eruptiones, Profluvia, Suppressorii, Spasmi, Adynamiæ, Paranoiæ, Cachexiæ, Intumescentiæ, Ectopiæ, and Plagæ. The orders are divided into genera and species, and these latter are still farther subdivided into varieties. In this distribution of the parts or members of his classification, he differs more in his literal method of employing the terms, than in the actual use which he makes of them; for his orders, genera, species, and varieties, are, in fact, nearly synonymous with the classes, orders, genera, and species of Cullen. What the latter calls classes, the former calls orders, and in the same manner with the rest.

The first order, the Pyrexiæ, contains three genera, Intermittens, Exacerbans, and Continua. Of the Intermittens there are five species, Quotidiana, Tertiana, Quartana, Erratica, and Complicata. Under the genus Exacerbans, by which is meant the remittent fever of other authors, we have the three species of Mitis, Maligna, and Hectica, and under Maligna, we have the three varieties of Autumnalis, Icterodes, and Asthenica. Under the genus Continua we have likewise three species, Synocha, Typhus, and Synochus; and under Typhus we have the three varieties of Cancerum, Neurodes, and Gastrica. The second order, the Phlegmasiæ, contains five genera, Inflammatio, Phlogosis, Catarrhus, Arthritis and Exostosis. Under Inflammatio are included most of the inflammatory topical affections attended with fever. There are 11 species, Phlegmon, Ophthalmia, Phrenitis, Cynanche, Pneumonia, Hepatitis, Carditis, Gastritis, Enteritis, Nephritis, Cystitis, Hysteritis, and Odontalgia. Several of these species are subdivided into varieties: under Ophthalmia we have Epidemica, Sporadica, and Tarsi; under Cynanche we have Faucium, Tracheæ, and Parotidea; under Pneumonia we have Pleuritica, Peripneumonica, Diaphragmatica, Hepatica, and Rheumatica. The second genus of the second order, Phlogosis, contains five species, Erythema, Phrenitica, Anginosa, Pneumonica, and Puerperalis. The third genus, Catarrhus, contains eight species; Coryza, which is subdivided into four varieties, Contagiosa, Senilis, Arthritica, and Trachealis; Dysenteria, of which there are the varieties Epidemica and Sporadica; Phthisis, Cœliaca, Leucorrhœa, Cystirrhœa, Gonorrhœa, and Leucorrhois. The fourth genus, Arthritis, contains 4 species; Rheumatismus, of which there are the three varieties, Lumbago, Ischias, and Pleurodyne; Arthrodynia, Podagra, and Hydrarthus, subdivided into coxarius and genu. The fifth genus, Exostosis, contains only one species, Periostea.

It would occupy too much space to pursue the whole of Dr. Parr's system into its minute subdivisions: what we have given above may serve as a specimen of his manner; and of the remaining part we shall merely mention the orders and genera. After the Pyrexiæ and the Phlegmasiæ we come to the Eruptiones; an order which may seem naturally connected with the last, as it is stated to consist of a number of local inflammations on the surface of the body. It is divided into the two genera of Exanthemata and Efflorescentiæ; the first term appropriated in the usual manner, and the latter including the cutaneous eruptions. The fourth order of Profluvia contains two genera, Hæmorrhagia and Apocenosis; the former, as its name imports, consisting of discharges of blood from various parts of the body, and the latter of increased discharges from glands and from cavities, into which the fluids from glands are occasionally poured. The Hæmorrhagies are a natural assemblage, and may be conceived to come properly enough after the febrile and inflammatory affections; but their connexion with the Apocenoses is rather apparent than real; while the Apocenoses themselves form but a heterogeneous collection, united together by a very slight bond of union. The fifth order, the Suppressorii, are the converse of the last; they are obstructions of natural discharges, and are divided into the genera of Constrictoria, signifying obstructions from organic disease; Anhelatio, obstruction to the passage of air into the lungs; and Epischeses, or obstructions of natural secretions. It may be objected to these genera, that they proceed upon different principles of arrangement, which may interfere with each other; while the second would seem to be merely a species of the first.

The 6th order is that of Spasmi: it contains two genera, Tonos and Clonos. The former of these terms is intended to express fixed muscular contraction; the second, muscular contractions alternating with relaxation: this use of the term may be, in some measure, sanctioned by use, but it seems scarcely compatible with the correct import of the words. It may be farther observed, that there is very little natural connexion between the diseases which compose the 2d genus, the Clonic spasm, either in their symptoms or mode of treatment. The 7th order, the Adynamiæ, contains the diseases which consist in a defect of sensation, motion, or of the ordinary functions, a definition which we think considerably too comprehensive to compose a natural assemblage of diseases, and which, if strictly adhered to, must include a great number of affections, which can have very little natural connexion with each other. It contains the two genera of Coma, diseases which consist in the loss of muscular power, with stupor, and Anepithymia, or diminution of action in some of the functions. The 8th order, the Paranoiæ, is composed of diseases which consist of violent or irregular exertions of the corporeal or mental functions, an assemblage that must be regarded as more artificial than natural, bringing together mental derangements of various kinds, which in a natural arrangement ought certainly to form a distinct family, with diseases of the digestive and sexual organs. The 9th order, the Cachexiæ, is defined a change of colour in the skin, generally from a chemical change in the nature of the fluids; an order which we think extremely objectionable, as it limits the character to a circumstance which is entirely artificial, leads to no general principle, and combines with this another circumstance, of a purely hypothetical nature and very dubious existence. Nothing, indeed, can be less natural than the group of diseases which it contains; Scorbutus, Syphilis, Aurigo, Phænigmus, Melasma, Rubigo, Ecchymosis, and Nævus.

The 10th order, the Intumescentiæ, defined enlargement of the whole body, or of particular parts, has very little claim to be considered as a natural assemblage of diseases: it consists of four genera, Tuber, or enlargement of the whole body, or of any of its parts, from whatever cause; Phlegmasiæ, increased bulk, with accumulated fluid; Cystis, increased bulk of a comparatively small part, or from a local cause; and Emphysema, or increased bulk, seemingly owing to a collection of flatus. This order is a very comprehensive one, but certainly has very little claim to be regarded as a natural arrangement, or as one that brings together diseases that have any natural connexion with each other. The remaining orders of Ectopiæ and Plagæ consist principally of local surgical diseases, the first comprising three genera, Hernia, Prolapsus, and Luxatio; the latter Dialysis, disunion of the soft parts; Clasis, disunion of the hard parts; and Diastasis, separated cartilages.

Upon the whole, we think Dr. Parr's system entitled to considerable commendation; his idea of arranging diseases into a set of natural groups, following each other in a connected manner, if it could be accomplished, would probably be the most appropriate and useful way of exhibiting the whole series of them. The attempt which we have been examining is, no doubt, in many respects, extremely imperfect, and, in some of its parts, it proceeds upon principles diametrically opposite to those on which it is professedly founded. We are, however, disposed to think, that the present state of medical science will not admit of a complete arrangement upon the plan which Dr. Parr has attempted; that we are not sufficiently familiar with the features of diseases, under all their forms, or sufficiently well acquainted with the nature of the morbid actions which produce their various modifications, to enable us to bring them together into that kind of connected chain, which may exhibit their relations to each other, and their mutual dependencies.

Of the late attempts which have been made in this country to improve the classification of diseases, we shall only notice those of Dr. Young and Mr. Good. Dr. Young's general method of arrangement the most nearly resembles that of Pinel, the great classes of diseases being derived from the structure or functions of the parts which they affect; but he has proceeded upon a more extensive view of the animal economy, and has accordingly produced a system which is much more perfect and comprehensive. A distinguishing characteristic of Dr. Young's nosology is, the employment of a great number of new terms, in consequence of his attempting to introduce a uniform nomenclature, in which all the names should be derived from the Greek language. No one could be better qualified for this task; and it is a question that is not easy to decide, in what degree it is desirable to alter established terms, for the mere purpose of introducing scientific uniformity.

He begins with the nervous diseases, which he calls Paraneurismi, and characterizes them as affecting the functions of sensation and motion; this class is not divided into orders, but it has eleven genera, expressive either of an excess of nervous power, a diminution of it, or its irregular action. The six first genera, Carus, Paralysis, Asthenia, Dysæsthesia, Autalgia, and Erethismus, are well marked and natural divisions; but with respect to the four next genera, Palmus, Pneusis, Clonus, and Entonia, which are respectively defined the irregular action of the involuntary muscles; the irregular action of the partially voluntary muscles; repeated contraction of a voluntary muscle; and a fixed contraction of a voluntary muscle; we consider the nice distinction that is attempted to be drawn between them, as an excess of nosological refinement, and that these different states of muscular contraction will be found so frequently alternating with each other, or occurring in immediate succession, as to render it impossible to separate them. With respect to the eleventh genus, Mania, we know so little of its pathology, and of its connexion with the physical part of our frame, that we think there is scarcely sufficient grounds for combining it with any other diseases.

The actions of the sanguiferous system, the Parhæmasiæ, as they are styled, form Dr. Young's second class, which is divided into the two orders of Phlogismi and Pyrexiæ, flushes and fevers; the first designated as affecting primarily the minute blood vessels; the second, as affecting the whole circulation and the constitution in general. We must object to the first of these orders, as being founded on too theoretical a principle; and with respect to the genera which it contains, we think the combination of inflammations and hæmorrhagies to be unnatural and entirely artificial. Under the Pyrexiæ, there are seven kinds of fever included; the Inflammatory, Erysipelatous, Mixed, Typhous, Paludal, Catarrhal, and Hectic.

Dr. Young's third class is styled Pareccrises, or secretory diseases, such as affect the functions of secretion and excretion. It contains the three orders of Epischeses, Apocenoses, and Cacochymiæ, or the effusions, retentions, and cachexies, characterised by the secretions being diminished, increased, and vitiated. There is a natural foundation for this class, as it is here constituted, but we think it has acquired too much of an artificial character, in consequence of the primary diseases of the digestive organs being placed under it, where the occurrence of the vitiated secretion is accidental, if not altogether hypothetical.

The fourth class, the Paramorphiæ, or structural diseases, affords, in many respects, a useful point of nosological arrangement, although the diseases which are brought together under it by Dr. Young have many of them little connexion with each other. It consists of two orders, the Paraphymata, or local changes, and the Epiphymata, defined " structural diseases frequently repeated, especially on the surface of the body, the whole system appearing to be affected." The first order contains fourteen genera, consisting of tumours of all kinds, dropsies, tympanies, obstructions, curvatures, and contractions, diseases which, for the most part, agree in the artificial circumstances of the change of structure, which is principally local, (although this character is not applicable to the dropsies,) but they have little natural relation to each other. With respect to the Epiphymata, we think there is sufficient ground for criticism. It contains most of the cutaneous eruptive diseases, which may be properly enough placed together; but with these are combined Syphilis, Scrofula, and Scorbutus, which present characters completely dissimilar, and can only be brought into the same class by a forced and unnatural construction.

The fifth class of Ectopiæ is properly allotted to mechanical affections, but along with these are included Venenatio, Parasitismus, and Dysodontiasis, which are scarcely reducible under the general character. These remarks will show that we do not consider Dr. Young's system as perfect, or as incapable of improvement, yet we regard it as decidedly superior to any which had been previously published. The classes are more natural than Cullen's; the divisions into orders and genera proceed altogether upon more correct principles of pathology; while it is much more complete and comprehensive than Pinel's system, and is much more minute in the distribution of the species and varieties. It proceeds upon no arbitrary or theoretical data, at least in its more essential parts; and its defects seem principally to arise from the author's desire to finish every part of it with equal precision, and not to leave any disease unappropriated, or without determining its exact relation to all the other parts of the system. This has evidently led to the employment of some artificial characters, and to the adoption of some principles of classification, which are little more than nominal distinctions, and which can throw no light upon the nature of the diseases in question.

The last system of nosology which has appeared in this country is one by Mr. Good, which has considerable claim upon our attention, both from its originality, and from the abundant proof which the author has given of his learning and industry. His professed object is to unite physiology with pathology, or rather to compose a pathological system upon the basis of physiology. Hence the principle of his arrangement is to class diseases according to the functions which they affect; and they are placed in the following order: 1st, The digestive functions; 2d, The respiratory functions; 3d, The sanguiferous functions; 4th, The nervous function; 5th, The sexual function; 6th, The excerning function; to which is added, as a kind of appendix, a 7th class of " fortuitous lesions, or deformities." These form the seven classes, the orders of which are chiefly taken from the local situation of the parts diseased. In the 1st class, the diseases of the digestive functions, the orders are two; those affecting the alimentary canal, and those affecting the collatitious viscera, as he terms them, the viscera auxiliary to the digestive organs. The diseases of the respiratory functions are likewise divided into two orders; those affecting the vocal avenues, and those affecting the lungs themselves. The 3d class, the diseases of the sanguiferous function, is necessarily of a more general nature, inasmuch as all parts of the body are more or less connected with the circulation. Its orders are not, therefore, derived from local situation, but from the nature of the morbid change; they are four, fevers, inflammations, eruptive fevers, and cachexies. The diseases of the nervous function have four orders; those which affect the intellect, the sensations, the muscles, and such as affect several or all the sensorial powers simultaneously. The 5th class, the diseases of the sexual function, is divided into three orders; those affecting the fluids, the orgasm, and the impregnation. The diseases of the excernent function are likewise divided into three orders; those which affect the parenchyma, the internal surfaces, and the external surface; and, lastly, the 7th class, which has three orders; diseases affecting the hard parts, those affecting the soft parts, and monstrosities of birth.

The genera are necessarily formed upon different principles, according to the different circumstances of each particular case. In the first order of the 1st class, the diseases affecting the alimentary canal, there are 13 genera, which are derived from the parts affected; they are, diseases of the teeth, of the salivary glands, and of the pharynx, excessive thirst, excessive desire for food, colic, costiveness, dysentery, diarrhœa, cholera, calculous concretions in the bowels, worms, and diseases about the anus. The diseases affecting the collatitious viscera, which form the second order of the 1st class, are divided into four genera, jaundice, melæna, gall-stone, and enlargement or scirrhus of any of the parts. In the 2d class, the diseases of the respiratory function, the first order, those which affect the vocal avenues, contains six genera; they are, coryza, polypus, hoarseness, loss of voice, imperfection of the voice, and imperfection in the articulation. The second order of this class, the diseases which affect the lungs, is divided into six genera; cough, dyspnœa, asthma, including angina pectoris, and pain of the side. So far the negative character of absence of fever is supposed to apply to all the diseases which we have hitherto enumerated.

The genera of Mr. Good are divided into numerous species, and these are again subdivided into varieties: we shall give some specimens of these divisions from the two first classes. The first genus, the diseases of the teeth, contains seven species, and some of these species as many as four varieties; the diseases of the salivary glands contain three species, under which are six varieties; and the diseases of deglutition are arranged under five species. The fifth genus, which is defined "the appetite for food impaired, excessive, or depraved," the Dyspepsia of former authors, is one of considerable importance; it contains seven species. The first is the Bulimia of former authors, "the insatiable craving for food," which contains three varieties, from a feeling of inanition, from habitual indulgence, and from exhaustion. The second species is simple loss of appetite, under which there are three varieties, that arising from too great fatigue, from passions of the mind, and from other causes, enabling the stomach to dispense almost entirely with food. The third species is perverted or deranged appetite, of which there are two varieties, that from want of discrimination, and that from a corrupted taste. The fourth species is heartburn, the Cardialgia of former authors, which contains the three varieties, in which the uneasiness is felt at the cardia, about the stomach generally, and that which is attended with watery eructations. The fifth species is flatulence, divided into the three varieties of flatulence, attended with rumbling of the bowels, with frequent eructation, or with frequent rejections of the wind downwards. The sixth species is tendency to vomiting, containing the varieties of nausea, ineffectual efforts to vomit, and the actual rejection of the food; the seventh and last species is the difficulty or imperfection of the digestion, under which are the varieties of indigestion occasioned by a sedentary life, by a transfer of some disease, and by antipathy to particular kinds of food.

The sixth genus, Colica, contains six species, under which are nine varieties; the seventh genus, Constipation, contains two species; the eighth, Dysentery, likewise contains two species; Diarrhœa contains six, simple increase of quantity, the quality being bilious, mucous, chylous, serous, or the food passing undigested. Cholera has three species; of the calculous affections there are three species; of worms there are three; and of the diseases affecting the anus, without primary inflammation, there are five; these are, simple pain of the part, morbid contraction of it, tenesmus, piles, of which there are four varieties, blind, mucous, bloody, and polypous; and lastly, inversion or prolapsus of the rectum, of which there are two varieties, the simple displacement of the part, and the disease attended by a spasm of the sphincter. It would carry us too far to examine the whole of Mr. Good's system through all its minute details; what we have given may serve as a specimen of the method which is adopted in its more minute arrangements, and we shall now proceed to offer some observations upon its general merits and defects.

The general aspect of Mr. Good's system is certainly imposing; it seems to present to us all the diseases to which the human frame is incident, in a well-arranged and perspicuous order, in which each occupies its appropriate place, and where we are led on from one to the other in the most regular succession. A considerable degree of this regularity it in fact possesses, but we shall probably find upon a closer inspection, that it is rather the regularity of an artificial than of a natural system. Its fundamental principle is the classification of diseases according to the organs which they affect; but most parts of the body are so formed, that they are liable to become the subject of various descriptions of diseases, and it also very frequently happens, that more than one of the regions into which the author divides the body is affected at the same time. But this is not its most exceptionable part; although local situation is the basis of the arrangement, and in the first class, at least, is the only bond of union; yet there are other classes which consist of general diseases, or at least of such as affect a considerable part of the corporeal frame. These latter classes necessarily include a part or the whole of the diseases that enter into the former, so that either the same diseases must occur twice in the system, or one of the classes must be left imperfect. The most palpable example of this occurs with respect to the first class, the diseases of the digestive organs. These constitute a set of morbid affections that have as little natural connexion with each other as any that could have been selected, with respect either to their pathology or their treatment; they only agree in having their seat in some parts that are more or less attached or connected with the digestive function. But the diseases of the blood-vessels, including fevers and inflammations, are reserved for the third class, so that the inflammation of the stomach and bowels are excluded from the first division, in order that they may come into the third. In the same way diseases of the nervous system constitute a class, and also diseases of the secretory organs, but to these, like the diseases of the sanguiferous system, nearly all the parts of the body are incident, so that the first, second, and fifth classes, which depend solely upon local situation, interfere with the third, fourth, and sixth classes, which depend upon the affection of organs or structures that are common to all parts. How, indeed, can we form a complete class of the diseases of the digestive function, or of the secretory function, when we are constrained, by the nature of the arrangement, to exclude from them the diseases which affect the blood-vessels, the veins, and the secretory organs?

With respect to the formation of Mr. Good's orders, genera and species, the same kind of observations apply as to his classes. There is often considerable ingenuity displayed, and they present the appearance of a natural method; but we shall not unfrequently find that it is the appearance more than the reality, and that the author seems rather to have imagined what would form a beautiful system, than given us what actually exists. Although professing to unite physiology with pathology, and thus mutually to illustrate one of these by the other, so as to render his nosology more natural in consequence of this union, we think that the author has produced a system which is probably less natural than almost any one which had preceded it, although we admit that it is better arranged, and possessed of a greater degree of artificial regularity. The same kind of minute and technical classification is apparent in the division of the genera into species, and the species into varieties; the author has appeared more anxious to insert contingencies, under which morbid affections might be supposed to take place, than to consider what were those which really existed, and to place them in the most convenient and appropriate order.

We have hitherto said nothing about a very prominent part in Mr Good's work, the nomenclature which he employs. He is the greatest innovator, in this respect, of any author that has passed under our review; and, indeed, he sets out with fully declaring his intention to spare nothing, however venerable for its antiquity, or by whatever authority it may be sanctioned, unless it come within the pale of his system. His general principle is, upon the whole, correct: he prefers those denominations that are immediately taken from the old classical writers, or directly derived from classical terms; but in carrying this into effect, we think he has attempted too much,—for although we admit that the Greek and Latin languages have a claim upon us superior to all others, yet it is an affair rather of conventional than of absolute excellence. Provided the names that are employed be sufficiently explicit in their meaning, generally adopted, and not liable to any uncertainty in their application, it is preferring an arbitrary system to every principle of common sense and accommodation, to discard them in favour of newly coined words, which must often necessarily be harsh and discordant, and which every succeeding writer will think himself at liberty to set aside with as little ceremony as Mr Good has exercised upon those that had been employed by his predecessors. If a complete new plan of nomenclature were to be found necessary in medicine, analogous to what took place a few years ago in the science of chemistry, we know few men who would be better qualified for the task; but we do not think that this is the case. In medicine we are not to expect that burst of discovery which has distinguished chemical science. The actual discoveries are necessarily few; and although we have great changes in our hypotheses, and our modes of reasoning, yet it depends more upon considering old subjects in a novel point of view, than in any absolute addition of new matter, or the development of any really new principles.

SECT. III. *Nosological arrangement of Diseases.*

IN the attempt which we shall make to form a nosological arrangement of diseases, the larger divisions of the classes and orders will the most nearly resemble those of Dr. Young, although generally divided into smaller portions; while the genera and species will, for the most part, be taken from Cullen. As the determination of the species will be more conveniently referred to the latter part of this article, we shall set out by inquiring what are the principles of the animal economy upon which our nosological arrangement is to be founded? And here we must refer to the remarks that we made above, in laying down the doctrines of pathology and therapeutics, as these doctrines will necessarily be our guide on the present occasion. We there stated, that the functions of the living body might be referred to certain systems, or sets of operations, which are, in some degree, independent of each other, and serve distinct purposes; that of the heart and blood-vessels, of the brain and nerves, of the digestive organs, and of those destined for absorption and secretion. Each of these systems is governed by its appropriate laws, and possesses actions and properties peculiar to itself, which necessarily influence the character of its affections, both natural and morbid, and suggest, in each case, a peculiar and specific mode of arrangement.

The changes in the sanguiferous system, for example, depend upon the greater or less degree of irritability of the muscular fibre, upon the greater or less degree of sensibility of the nerves, and also upon the state of the nutritive system, as occasioning variations in the quantity of the blood assimilated and carried into the circulation. The nervous system being, as it were, more detached from the other parts of the animal economy, and less essential to their existence, is less under the influence of any changes which they may experience; and therefore its affections will depend principally upon the greater or less degree of its own powers of action. With respect to the other systems, we may begin by the action of the stomach upon the alimentary mass received into it; we may then proceed to that of the intestinal canal upon its contents; afterwards to that of the absorbents and glands that receive and elaborate the chyle; and, lastly, to the different secretory organs, the diseases of which may be arranged according to the quantity and quality of the various substances which they produce.

To begin with the diseases which primarily depend upon a derangement of the natural actions of the sanguiferous system. To these, which form our first class, we shall apply the term *Parhæmasiæ*, or sanguine diseases, and shall divide them into three orders, according to their connexion with the other systems. 1*st*, Those which essentially consist in an altered action of the heart and arteries alone; 2*d*, Those where the sanguiferous and nervous systems are both of them essentially affected; and, 3d, Those where the disease seems to consist in some change in the quantity and distribution of the blood, to a certain degree independent of any morbid action of the vessels. The first of these orders, which will be found to consist in increased action of the sanguiferous system, nearly coincides with the phlegmasiæ of Cullen; but as he makes a local affection an essential part of his definition, which forms the character of one of our genera, we shall prefer the name *Phlogismi.* Our second order is intended to embrace the Febres of Cullen, and the Pyrexiæ of Dr. Young. We employ the latter of these terms, because we shall find it convenient to use the word Febris as a generic title. The third order of the parhæmasiæ comprizes the hæmorrhagies, and may be properly designated by this title.

With respect to the subdivision of the orders. The Phlogismi may be considered as containing at least two well marked genera—inflammation of a viscus, accompanied with fever, and the inflammation of a mucous surface, connected with an increased discharge from the glands of the parts, and likewise attended with fever. Besides these genera, which contain several species, we have inflammatory fever without local affection, and inflammation of the muscular parts, properly constituting generic characters, but where there is no more than one species referable to each of them. There are also some diseases which may be placed among the phlogismi, but where their nature is not sufficiently ascertained to enable us to reduce them to their appropriate genera.

In enumerating individual diseases, we shall begin with those which are more general in their operation, and are the most acute and well marked; and shall asterwards proceed to such as are of a more limited and indeterminate nature. It is a question, which is still undecided, whether it be possible for a general inflammatory action to exist without the affection of any particular organ. It will, however, be proper, at all events, to retain a place for simple inflammatory fever, as it is often found convenient to refer to this condition of the system, even although we conceive it to be sympathetic, or necessarily connected with some other disease. This general inflammatory state of the vessels is the Synocha of Cullen; but as this denomination is only significant, as contrasted with intermittents, and is not expressive of the characteristic circumstance of inflammatory fever, we prefer Dr. Young's term, Cauma. Next to Cauma will come the Phlegmasiæ, a genus of diseases which consist in the inflammation of some of the viscera, accompanied with fever. They are commonly local in their origin, and the seat of the complaint constitutes the chief specific difference between them. Of these we may enumerate the following: Phrenitis, Parotitis, Tonsillitis, Laryngitis, Trachitis, Peripneumonia, Pleuritis, Hepatitis, Carditis, Gastritis, Enteritis, Splenitis, Nephritis, Cystitis, Hysteritis, and Peritonitis. These names are sufficiently indicative of the diseases which they are intended to represent. The Cynanche of Cullen is discarded, as being an attempt to combine diseases which are in reality distinct; and we have substituted for it four specific affections, which depend upon the inflammation of the parotid gland, of the tonsils, the larynx, and the trachea, respectively.

Besides these inflammations, in which some organ of considerable bulk is concerned, and which, by the extent and violence of the affection, are accompanied with fever, there are inflammations of smaller organs, which are frequently so much circumscribed as to produce no general disturbance of the system. Of these, the most important are Ophthalmia, or inflammation of the eye; Otitis, or inflammation of the ear, that of the breast, and of the testicle; but notwithstanding the absence of general fever, they seem to belong essentially to the Phlegmasiæ; for this circumstance appears to depend entirely upon the small bulk of the part inflamed, or its less intimate connexion with the other parts of the body, so that it is a point entirely of degree.

The next genus of Phlogismi consists of the Defluxiones, inflammatory affections of a mucous membrane, producing an increased secretion from the glands of the part, and accompanied with fever. Of these, the most important are Catarrhus and Dysenteria, to which we may perhaps add Bronchitis. After the Phlegmasiæ and the Defluxiones, which consist respectively of the inflammation of particular viscera, and of the mucous membranes, we come to the inflammation of the membranous parts connected with the muscles, accompanied with fever, constituting Rheumatism; and we also insert in this part of our system Phlogosis and Erythema, the one consisting of the inflammation of the cellular texture, the other of the skin; which, although differing in some respects from the other diseases of this order, seem to have a natural connexion with them. As an appendage to this order, we may also place Hectica, a disease of an ambiguous nature, and one which exhibits some remarkable peculiarities. In most instances, Hectica is clearly a secondary disease, sympathetic of an affection of some of the viscera: but there are cases in which the primary complaint can scarcely be detected; and it frequently happens that the hectic becomes the prominent object of our attention, while it consists of a well-marked train of symptoms, which it is necessary to recognize as a specific affection.

We now come to the important order of the Pyrexiæ, diseases of the most fatal tendency, and which exist under circumstances that render them most destructive in their operation, and frequently beyond the power of human skill to prevent or mitigate. Although we regard them as fundamentally consisting of a derangement of the sanguiferous system, yet it is obvious that the nervous system is also much affected, and partakes, in a specific manner, of the general disturbance. We may divide them into Febres, those diseases which consist simply of the febrile paroxysm, and those which, in addition to the fever, are attended with a cutaneous eruption of a specific kind, which appears at a certain stage of their progress, and constitutes an essential part of their nature; to this genus the name of Exanthemata has been applied.

No part of medicine has given rise to more discussion than the nature of fever, and the relation which the different forms of it bear to each other; these topics will be considered more fully in the latter part of this article; at present we shall only enter upon this so far as is necessary for the formation of our arrangement. The species of fever, which are probably not numerous, may be determined partly by the nature of the cause producing them, and partly by the symptoms which they exhibit. The first circumstance which forms a clear mark of distinction, is their being continued or intermittent; another important point respects their property of being communicated by contagion; and we also enquire whether they originate from any specific cause acting upon the body, or from some morbid state of the system arising from a change in some of its functions, not necessarily connected with external circumstances.

Proceeding upon these principles, we may designate three distinct kinds of fever, 1. Intermittens, consisting, as its name imports, of distinct paroxysms with an interval interposed between them, probably always produced by marsh effluvia, and not contagious. 2. Typhus, a disease without any intermission, communicated by contagion, and perhaps never originating from any other cause. And, 3. The pestilential fever of hot climates, a disease which seems not to be communicated by contagion, and not to be necessarily connected with marsh effluvia, but which probably depends upon the combined operation of particular states of the air, a certain range of temperature, and a peculiar condition of the constitution. Under these species we shall find it necessary to include a great number of varieties; and the more we investigate the subject, the more difficulty shall we have in discovering what are the original species, and what the varieties, what connexion they bear to each other, and how far they are each of them modified by different states of the body, or by external circumstances. Of the three species which we have pointed out, the typhus, as originating from a specific contagion, must be regarded as forming a definite disease like variola; and we shall find that it maintains its distinguishing characters with as much uniformity as can be expected from any complaint of such frequent occurrence, and which affects so many parts of the system. But the other two species, although they ex hibit well marked features, when existing in the acute state, yet they appear to be capable of assuming the mixed or hybrid form, and of producing certain combinations, which unite the characters of each. All the tribe of remittents will come under this description, and to this combination we feel disposed to refer the yellow fever of America and the West Indies.

We now come to the second division of the Pyrexiæ, the Exanthemata, which may be characterized as consisting of fever, attended at a certain stage of its progress with a cutaneous eruption, which, like the fever, has a regular period for its continuance. The exanthemata have several circumstances of a peculiar nature belonging to them; they are all produced by a specific contagion, and from no other cause; they only occur once to each individual; and, in however slight a degree they may have existed, the patient is not liable to a second attack. Of these we may enumerate Variola, Vaccinia, Varicella, Scarlatina, and Rubeola, to which the above character strictly applies. There are others of a more doubtful nature, and less thoroughly understood, as Urticaria and Pemphigus; and we shall also place in this division Erysipelas, although in some points it does not coincide with the exanthemata.

The Hæmorrhagiæ form the third and last class of the Parhæmasiæ. There seems no doubt of the propriety of placing them in this part of the system, although there is considerable obscurity concerning their proximate cause, or the nature of the circumstances which immediately give rise to them. Although sometimes attended with fever, they are not necessarily connected with it, nor with topical inflammation, although these two states may be coincident. The previous step in the order of morbid actions would appear to be an irregular distribution of the blood, or its disposition to accumulate in certain vessels; but whether this depends upon any peculiar condition of the individual vessels, upon some irregularity in the general action of the sanguiferous system, or upon an absolute increase in the total mass of blood, are points upon which at present we shall not attempt to decide. It has been usual to divide the hæmorrhagies into active and passive; and although we cannot always draw a clear line of distinction between them, yet there is a foundation for this division: they are generally named from the part whence the blood proceeds; the most important of them are Epistaxis, Hæmoptysis, Hæmatemesis, Hæmorrhois, Hæmaturia, and Menorrhagia. To these might perhaps be added the discharge of blood from the mouth, the liver, and the intestinal canal, but all of these may be more properly regarded as symptomatic of some more general affection.

We now come to the second great class of diseases, those which depend primarily or principally upon a derangement of the brain and nerves. These diseases, to which we shall apply Cullen's term of Neuroses, may be arranged according to the degree in which they affect the functions of the nervous system, and will naturally divide themselves into three orders; of those which morbidly increase their action, those which diminish it, and those which render it irregular: we shall denominate them, respectively, Erethismi, Astheniæ, and Spasmi. The increased action of the nervous power, which we may denominate Erethismus, although frequently a well marked condition of the system, is seldom unconnected with other morbid affections, so that it generally appears either as a symptom, or it immediately gives rise to some other disease, which then becomes the more immediate object of attention. Occasionally, however, we observe it to exist without the production of any other disease; of this description is Agrypnia, or want of sleep, when arising from simple restlessness, and various affections which seem to be either modifications or different degrees of it, as Oneirodynia, Incubus, and Somnambulismus. The external senses are liable to have their power morbidly increased; and the same increase of nervous power is also observable in some of the organic functions, for example, in the stomach, the urinary and generative organs, and, as far as we can judge, without any derangement of their structure. Hence we have increased sensibility of the eyes, the ears, and the palate, perhaps of the touch generally, although these are usually only symptoms of some more general affection; while Bulimia, Eneuresis, Satyriasis, and Nymphomania, appear to have more claim to be considered as primary and idiopathic. To the order of Erethismi we feel disposed to add Hydrophobia, although we acknowledge that the theory of this disease is but imperfectly understood. The Autalgiæ, or pains of particular parts which are not sympathetic of other affections, will form a genus of the Erethismi; of these the most important are Neuralgia, Cephalalgia, Prosophalgia, Otalgia, Odontalgia, Mastodynia, Pleurodyne, Gastrodynia, Sciatica, and Pruritus: perhaps to this list we ought to add Lumbago.

To the diseases which consist in a diminution of the nervous energy, we shall apply the term Astheniæ, and shall arrange under this order both those which seem to arise from the mere decrease of the natural powers, and such as depend upon a loss of this power, proceeding from some specific cause or more direct injury. There are certain states of fever, which, both from their origin and from their symptoms, would seem to proceed primarily from this cause, and which, during their whole progress, affect the nervous functions, no less remarkably than the ordinary typhus does those which belong more exclusively to the sanguiferous system. At the same time, it must be confessed, that the gradations by which these, which may be called nervous fevers, run into the proper typhus, or putrid fevers, are so insensible, that in many instances it is absolutely impossible to decide to which division the individual cases should be referred. This, however, is no proof that the diseases both proceed from the same primary cause, but rather may be adduced to illustrate the intimate connexion which subsists between the different sets of functions, so that one of them cannot experience any considerable derangement, without communicating a proportionate effect to the other. We shall not therefore hesitate to include nervous fevers among the Astheniæ, although by this arrangement we may seem to fall into the inconsistency of placing in different classes two diseases, which so nearly resemble each other, and are so frequently connected together.

Among the Astheniæ, which depend upon a general diminution of the nervous energy, we may place Tremor, Syncope, the various defects of the external senses, and those of the organic functions, as Aphonia, Dysphagia, Anorexia, Eneuresis, and Anaphrodisia, when they do not arise from any derangement of the structure of the respective organs. To the 2d division of the Astheniæ, we shall refer Apoplexia, Paralysis, Hydrocephalus, and Lethargus, where the loss of nervous power is generally to be ascribed to some obvious and specific cause, acting immediately upon the brain itself, or some of the larger nerves.

The 3d order of the Neuroses, which are denoted by an irregular action of the nervous system, we shall comprise under the title of Spasmi. They may be arranged according as they more specifically affect the voluntary or the involuntary muscles; to the first belong convulsions of all kinds, Epilepsia, Hysteria, Chorea, Trismus, Tetanus, and Catalepsia; among irregular actions of the involuntary muscles, we may include Palpitatio, Vomitus, perhaps Colica; and as intermediate between the two, originating in muscles that are possessed of only an imperfect degree of voluntary power, we may place Tussis, when idiopathic, Pertussis, Dyspnœa, Asthma, perhaps Angina pectoris, together with Singultus, and some other affections of the thoracic viscera, which are of minor importance, and always sympathetic of other diseases; as well as some affections that belong to muscles immediately connected with the organs of sense, as Strabismus.

After the Neuroses, we must place the Vesaniæ, including all the varieties of mental diseases, which we think it better to put in a separate class, because, although they are evidently connected with a derangement of the nervous system, yet the nature of the derangement, and the relation which it bears to the physical condition of the brain and nerves, is very obscure. This class naturally divides itself into two orders, Mania and Amentia, denoting, respectively, the irregularity and the abolition of the intellectual powers.

We now come to our fourth great class of diseases—those which primarily affect the functions that are concerned in nutrition. This term is employed in its most extensive application, not referring merely to the function of digestion, but to all the various processes by which the component parts of the body are preserved in their state of health, including the action of the stomach, intestinal canal, and absorbent system. To the diseases that belong to this class, we shall give the title of Paratrepses, which, although not unobjectionable, seems, upon the whole, less so than any other with which we are acquainted. This class may be divided into, 1*st*, The diseases of the stomach itself, as affecting the system either directly or indirectly; 2*d*, The Cachexiæ, the diseases which tend to produce a morbid state of the component parts of the body; 3*d*, Dropsies of all kinds; and 4*th*, Cutaneous diseases. They may be arranged, in the first instance, according to the particular organ which they affect; and, with respect to each organ, we may regard them either as they visibly alter its structure, or merely produce some irregularity in its function, when the morbid condition is not immediately referable to that action of the blood-vessels which constitutes inflammation, or to a mere perversion of the nervous energy.

We may begin with the stomach, where we shall have Dyspepsia, a comprehensive term, employed to embrace a long train of symptoms that are connected with a defect in the process of digestion; and Pyrosis, the consequences of which are principally confined to the organ itself; while Podagra and Diabetes, although probably originating in the derangement of the stomach, manifest their effects in other parts of the system. To the same order we shall also add Atrophia, Pica, and Aphtha, as all of them, in their ordinary form, seem to depend primarily upon a defect in the digestive organs.

Among the Cachexiæ, we shall first place Scrofula, a term which has frequently been employed in a very indeterminate manner, but which we conceive ought to be limited to a disease of the absorbent glands; and connected with the same system, although possessed of peculiar characters, and confined to a particular part of the body, we have Phthisis. In the various secreting glands, besides the affections immediately connected with their peculiar functions, we have Scirrhus and Cancer, to which they appear all of them to be more or less subject; and in the bones and joints we have Rachitis and Arthoquosis. Next we have some diseases which seem properly to come under the designation of Cachexiæ, but which depend upon a specific cause, as Syphilis and Scorbutus; perhaps also Frambœsia and Elephantiasis; and to the same list we may add Gangræna, when occurring spontaneously, and not as the consequence of local injury.

A very important set of diseases next comes to be considered, depending upon a morbid condition of the minute vessels connected with the serous membrane, which lines the close cavities that exist in various parts of the body. These constitute the order of dropsies. Under the general denomination of Hydrops we include Anasarca, an effusion of a serous fluid into the minute cavities of the cellular texture that lies below the skin, or between the muscles, which may take place, either in the whole body generally, or, by the operation of local causes, may be confined to particular parts of it. Of these local Anasarcæ, the only one which requires to be particularly noticed is that which occurs in the substance of the lungs. Of the dropsies that are effused in larger or more defined cavities, the principal are Hydrocephalus, which, however, in consequence of the peculiarity of its symptoms, we have been induced to transfer to another part of the system; Hydrorachitis, or dropsy of the spinal sheath; Hydrothorax, of the cavity of the thorax; Hydrops pericardii, of the pericardium; Ascites, of the peritoneal cavity of the abdomen, which is sometimes general, and sometimes confined to one part by a distinct bag or cyst; Hydrops ovarii, Hydrops uteri, and Hydrocele, dropsies of the ovarium, uterus, and scrotum. As an appendage to this order we may place the singular affection of Hydatis.

The fourth order of the Paratrepses we have allotted to the eruptive diseases of the skin, which are not attended with fever. Many of the cutaneous affections are obviously connected with particular states of the nutritive functions; they originate from causes which operate through the intervention of these functions, they are affected by circumstances which act upon them, and are relieved by constitutional remedies. There are, indeed, others which appear to be entirely local; but, upon the whole, it will be found convenient to place them all in this part of the system, rather than to separate diseases which are so strictly connected together.

We now come to our fifth class, the diseases of the secreting organs, which are connected with their appropriate functions: these we denominate Pareccrises. They may be considered as acting either in an excessive or a defective manner, giving rise to a division of them into the two orders of Apocenoses and Epischeses.

With respect to the organs which they affect, those which most frequently fall under our notice, as objects for medical attention, are the intestines, the liver, the urinary organs, and the uterus. Among the Apocenoses we have Diarrhœa and Cholera, as affecting the intestines and the liver; Hyperuresis, Blennorrhœa vesicæ, and we may add Lithiasis, as affecting the urinary organs. The discharges from the uterus are Menorrhagia, or an increase of its specific secretion, which, however, in consequence of its resemblance to the Hæmorrhagies, has been placed along with them; and Leucorrhœa, or an increased secretion from the mucous glands of the part; and in this order we have also Ptyalismus, Ephidrosis, and some other affections of less importance. The principal of the Epischeses are Obstipatio, Icterus, and Cholelithia, as affecting the intestines and the liver; Ischuria, as affecting the urinary organs; and Amenorrhœa, as affecting the uterus; to which, as intimately connected with this last disease, we may add Chlorosis.

We have now gone through the consideration of all the diseases which can be considered as immediately originating from a morbid state of any of the functions connected with the great systems of the blood-vessels, the nerves, and the organs of digestion, absorption, and secretion; but many others still remain to be noticed. We have a large class of what may be termed structural diseases, where there is a change in the shape or structure of a part, which is not the obvious consequence of any previous affection, and is not essentially connected with any constitutional derangement. It must be admitted that many cases will occur, where we shall find it extremely difficult to draw the line between general and local affections, and to decide in which class a particular disease should be placed. We shall also find, that the same morbid change in a part is sometimes the effect of purely incidental, and at other times of constitutional causes; so that, were we to adhere strictly to our arrangement, we should be obliged to separate affections which are strictly connected together. Yet this apparent contradiction seems to be the necessary consequence of the imperfection which must attach to all nosological arrangements; and the plan which we have adopted will probably be found to be both natural and convenient, although not without considerable objections. To this class of diseases we shall give the name of Paramorphiæ; a name which is expressive of their effect, although it does not indicate their local nature. If we consider the cause of these diseases, we might arrange them under two divisions; the one, where they were properly local and incidental, although originating from some change in the action of the part itself; the other, where it was the effect of obvious external injury.

Disregarding however the cause, we may class them more conveniently according to their effect, whether this consists in merely adding to the bulk of a part entirely changing its structure, or presenting some obstacle to the performance of its ordinary functions. The first of these divisions, which includes the numerous and important class of tumours, we shall denominate Phymata: they are to be considered not merely as the extension or enlargement of an organ previously existing, but frequently as an actual production of some additional substance. They may be arranged either according to the structure which they occupy, or according to the substance of which they consist. They may be seated in the cellular texture, immediately connected with a muscle, with the skin, in a gland, a mucous or serous membrane, a bone, a cartilage, or a ligament, or some other dense part. With respect to their consistence, the tumour may be composed of condensed membrane, of fleshy fibres, of bone, of fatty, albuminous or medullary matter, of pus, of a bloody, mucous, serous or aqueous fluid.

The next order of the Paramorphiæ we shall denominate Phtharmata, the diseases which consist of an alteration in the structure of the part; such as the conversion of a membrane into a bone, of a transparent membrane into one which is opake, of a soft part into one that is rigid, or of a hard part becoming soft and flexible. Under this class will come some diseases of the organs of sense; as in the eye, where the different parts of this organ have their structure so changed, as either not to admit of the rays of light, nor to suffer them to form a distinct picture upon the retina, or, in consequence of some change in the structure of the nerve, not to convey the impression to the sensorium. The same change of structure also occurs in the parts of the ear, although from their nature we are less able to detect them. Ossification, or the conversion of membrane into bone, and, conversely, mollities ossium, or the removal of the earthy matter from bone, so as to reduce it to the form of a membrane, may be referred to this class, and, as a consequence of this state, we may place the curvatures and deformities that occur in the bones, and in the general form of the body, when they have not been obviously produced by some other disease or local injury.

Some of the most important of the Phtharmata are, those diseases where, from a change of structure in the organs of circulation, this function becomes deranged. The thickening and ossification of the valves of the heart or of its arteries, and sometimes a change in the substance of the heart itself, will interfere with its regular actions, produce some of the most fatal diseases to which the body is liable, and, at least in many cases, do not appear, except as to their effect, to be connected with any constitutional derangements. The diseases in the large blood-vessels, producing aneurism in the arteries, and varix in the veins, and a thickening or even total obliteration of some of the tubes or passages destined for the transmission of other substances besides blood, which form the different species of contractions, may also be placed among the Phtharmata, because, although there are some cases in which the change of structure is not very considerable, yet it always exists in a certain degree, and it is impossible to draw any exact line between those cases where the structure is deranged, and those where the function alone is injured. Among the contractions, the most important are those of the œsophagus, of the orifices of the stomach, of the various parts of the intestinal canal, particularly of the rectum, of the urethra, the gall duct, the pancreas, and some others of less importance.

A 7th class of diseases still remains, which are entirely of a mechanical nature, consisting in the mere displacement of certain parts, whether produced by external violence, or from some internal cause affecting the relation of the parts to each other. These constitute the surgical diseases, and will therefore form no part of our present object. They consist principally of luxations, fractures, contusions, strains, ruptures, wounds, and local ulcers.

Synopsis of a Methodical Classification of Diseases.

CLASSES.

1. Parhæmasiæ
2. Neuroses
3. Vesaniæ
4. Paratrepses
5. Pareccrises
6. Paramorphiæ
7. Ectopiæ

Class I. PARHÆMASIÆ.

Orders.

1. Phlogismi
2. Pyrexiæ
3. Hæmorrhagiæ

Order I. Phlogismi.

Genera.

1. Cauma
2. Phlegmasiæ
    - Phrenitis
    - Parotitis
    - Tonsillitis
    - Laryngitis
    - Trachitis
    - Peripneumonia
    - Pleuritis
    - Hepatitis
    - Carditis
    - Gastritis
    - Enteritis
    - Splenitis
    - Nephritis
    - Cystitis
    - Hysteritis
    - Peritonitis
    - Febris puerpuralis ?
    - Opthalmia
    - Otitis
    - Inflammatio mammæ
    - Inflammatio testis
3. Defluxiones
    - Catarrhus
    - Bronchitis ?
    - Dysenteria
4. Rheumatismus
5. Phlogosis
6. Erythema
7. Hectica

Order II. Pyrexiæ.

Genera.

1. Febres
    - Intermittens
    - Typhus
    - Synochus icterodes
    - Pestis
2. Exanthemata
    - Variola
    - Vaccinia
    - Varicella
    - Scarlatina
    - Rubeola
    - Urticaria ?
    - Pemphigus ?
    - Erysipelas

Order III. Hæmorrhagiæ.

Genera.

1. Arteriosæ
    - Epistaxis
    - Hæmoptysis
    - Menorrhagia
2. Venosæ
    - Hæmatemesis
    - Melæna
    - Hæmorrhois
    - Hæmaturia
    - Hæpatirrhœa
    - Purpura ?
    - Stomacace ?

Class II. NEUROSES.

Orders.

1. Erethismi
2. Astheniæ
3. Spasmi

Order I. Erethismi.

Genera.

1. Hyperæsthesiæ
    - *a.* with increased sensibility of the whole system.
        - Agrypnia
        - Oneirodynia
        - Incubus
    - *b.* with increased sensibility of the organs of sense.
    - *c.* with increased action of the organic functions.
        - Bulimia ?
        - Polydipsia ?
        - Eneuresis
        - Satyriasis
        - Nymphomania
        - Hydrophobia ?
2. Autalgiæ
    - Neuralgia
    - Cephalalgia
    - Prosophalgia
    - Otalgia
    - Odontalgia
    - Mastodynia
    - Pleurodyne
    - Gastrodynia
    - Sciatica
    - Pruritus
    - Lumbago

Order II. Astheniæ.

Genera.

1. Febris nervosa
2. Anæsthesiæ
    - *a.* with general debility of the nervous system.
        - Tremor
        - Syncope
    - *b.* with deficient sensibility of the organs of sense.
    - *c.* with debility of the organic functions.
        - Aphonia
        - Dysphagia
        - Anorexia
        - Dysuria
        - Anaphrodisia
3. Dyscinesiæ
    - Apoplexia
    - Paralysis
    - Hydrocephalus
    - Lethargus

Order III. Spasmi.

1. Irregular actions of the voluntary muscles
    - Convulsio
    - Epilepsia
    - Hysteria
    - Chorea
    - Raphania ?
    - Trismus
    - Tetanus
    - Catalepsia
2. Irregular actions of the involuntary muscles
    - Palpitatio
    - Vomitus
    - Colica
    - Flatulentia
    - Tympanitis ?
3. Irregular actions of the semi-voluntary muscles
    - Tussis
    - Pertussis
    - Dyspnœa
    - Asthma
    - Angina pectoris
    - Sternutatio
    - Singultus
    - Dysæthesiæ
    - Dysopia
    - Strabismus
    - Paracusis
    - Parosmia
    - Parageusmia
    - Psellismus

Class III. VESANIÆ.

1. Mania
2. Amentia
3. Melancholia
4. Nostalgia

Class IV. PARATREPSES.

Orders.

1. Derangements in the functions of digestion
2. Cachexiæ
3. Hydropes
4. Cutaneous diseases

Order I. Diseases of Digestion.

- Dyspepsia
- Pyrosis
- Pica
- Diabetes
- Podagra
- Atrophia
- Aphtha

Order II. Cachexia.

- Scrofula
- Phthisis
- Rachitis
- Arthropuosis
- Scirrhus
- Cancer
- Syphilis
- Scorbutis
- Frambœsia ?
- Elephantiasis
- Gangræna

Order III. Hydropes.

- Anasarca
- Hydrocephalus
- Hydrorachitis
- Hydrothorax
- Hydrops pericardii
- Ascites
- Hydrops ovarii
- Hydrops uteri
- Hydrocele
- Hydatis

Order IV. Morbi Cutanei.

Class V. PARECCRISES.

Orders.

1. Apocenoses
2. Epischeses

Order I. Apocenoses.

- Diarrhœa
- Cholera
- Hyperuresis
- Blennorhœa vesicæ
- Lithiasis
- Cholelithia
- Menorrhagia ?
- Leucorrhœa
- Ptyalismus
- Ephidrosis

Order II. Epischeses.

- Obstipatio
- Icterus
- Ischuria
- Amenorrhœa
- Dysmenorrhœa

Class VI. PARAMORPHIÆ.

Orders.

1. Phymata
2. Phtharmata

Order I. Phymata.

Tumores

Order II. Phtharmata.

Structural diseases of the organs of sense

- Ossificatio
- Mollities ossium
- Neurosis
- Curvatura
- Organic diseases of the heart
- Aneurysma
- Varix
- Fistula
- Contractura

Class VII. ECTOPIÆ.

Morbi chirurgici

The American Editor has obtained liberty to insert the following new Classification of Diseases, recently proposed by Dr. Hosack of New York. It may not be superfluous to observe, that it is the first systematic arrangement of diseases attempted by an American physician. The principles upon which it is founded may be seen in the 'Practical Nosology' of the author, published in New York, 8vo. 1818.—Amer. Ed.

Classification of Diseases, *By* David Hosack, *M. D. F. R. S.*

Professor of the Institutes and Practice of Physic in the University of New York.

Class I. FEBRES.

Order I. Intermittentes.

1. Quotidiana
2. Tertiana
3. Quartana

Order II. Remittentes.

4. Remittens Biliosa
5. ——.—— Infantilis

Order III. Continuæ.

6. Synocha
7. Typhus vel Synochus
8. Dysenteria
9. Pestis Orientalis
10. Pestis Tropicus

Class II. PHLEGMASIÆ.

11. Phlogosis
12. Phrenitis
13. Ophthalmia
14. Otitis
15. Odontitis
16. Parotis
17. Mastitis
18. Catarrhus
19. Laryngitis
20 Trachitis
21 Bronchitis
22. Pertussis
23. Pneumonia
24. Diaphragmitis
25. Carditis
26. Phthisis
27. Glossitis
28. Tonsillitis
29. Pharyngitis
30. Œsophagitis
31. Peritonitis
32. Gastritis
33. Enteritis
34. Hepatitis
35. Splenitis
36. Pancreatitis
37. Nephritis
38. Cystitis
39. Urethritis
40. Orchitis
41. Proctitis
42. Hysteritis
43. Phlegmasia dolens
44. Rheumatismus
45. Arthritis
46. Periostitis
47. Paronychia

Class III. CUTANEI.*

Order I. Papulæ.

48. Strophulus
49. Lichen
50. Prurigo

Order II. Squamæ.

51. Lepra
52. Psoriasis
53 Pityriasis
54. Icthyosis

Order III. Exanthemata.

55 Rubeola
56. Scarlatina
57. Urticaria
58. Roseola
59. Purpura
60. Erythema

Order IV. Bullæ.

61. Erysipelas
62. Pemphigus
63. Pompholyx

Order V. Pustulæ.

64. Impetigo
65. Ecthyma
66. Variola
67. Scabies
68. Porrigo

Order VI. Vesiculæ.

69. Herpes
70. Varicella
71 Vaccinia
72. Miliaria
73. Eczema
74. Aphthæ

Order VII. Tubercula.

75. Phyma
76. Verruca
77. Molluscum
78 Vitiligo
79. Acne
80. Lupus
81. Elephantiasis
82. Frambœsia

Order VIII. Maculæ.

83. Ephelis
84. Nævus
85. Spilus

Class IV. PROFLUVIA.

Order I. Hæmorrhagiæ.

86. Epistaxis
87. Hæmoptysis
88 Hæmatemesis
89. Hepatirrhœa
90. Hæmaturia
91. Menorrhagia
92. Hæmorrhois

Order II. Apocenoses.

93. Ephidrosis
94. Epiphora
95. Otirrhœa
96. Ptyalismus
97. Galactirrhœa
98. Cholera
99. Diarrhœa
100. Diabetes
101. Enuresis
102. Leucorrhœa
103. Blennorrhœa
104. Gonorrhœa

Class V. SUPPRESSIONES.

105. Icterus
106. Obstipatio
107. Ischuria
108. Dysuria
109. Dyspermatismus
110. Amenorrhœa
111. Dyslochia
112. Agalactia.

Class VI. NEUROSES.

Order I. Dysæsthesiæ.

113. Asphyxia
114. Apoplexia
115. Paralysis
116. Amaurosis
117. Caligo
118 Dysopia
119. Pseudoblepsis
120. Strabismus
121. Paracusis
122. Anosmia
123 Agheustia
124. Paraphonia
125. Psellismus
126. Dysphagia
127. Anæsthesia

Order II. Adynamiæ.

128. Syncope
129. Dyspepsia
130. Satyriasis
131. Nymphomania
132. Anaphrodisia

Order III. Spasmi.

a. *In functionibus Animalibus.*

133. Tetanus
134. Neuralgia
135. Convulsio
136. Chorea
137. Epilepsia
138. Catalepsia

b. *In functionibus Vitalibus*

139. Angina Pectoris.
140. Asthma

c. *In functionibus Naturalibus.*

141. Colica
142. Nephralgia
143. Hysteralgia
144. Hysteria
145. Hydrophobia

Order IV. Vesaniæ.

146. Amentia
147. Oneirodynia
148. Melancholia
149. Hypochondriasis
150. Mania

Class VII. CACHEXIÆ.

Order I. Marcores.

151. Marasmus

Order II. Intumescentiæ.

a. *Sanguineæ.*

152. Plethora

b. *Adiposæ.*

153. Polysarcia

c. *Flatuosæ.*

154. Emphysema
155. Tympanites
156. Physometra

d. *Aquosæ.*

157. Hydrops Cellularis
158. Hydrops Cerebri
159. Hydrops Spinæ
160. Hydrops Thoracis
161. Hydrops Abdominis
162. Hydrops Uteri
163. Hydrops Ovarii
164. Hydrops Testis
165. Hydrops Articuli

e. *Solidæ.*

166. Physconia

Order III. Vitia.

167. Rachitis
168. Fragilitas Ossium
169 Mollities Ossium
170. Lithiasis
171. Scrophula
172. Syphilis
173. Scorbutus
174. Plica

Class VIII. LOCALES

Order I. Tumores.

a. *Hematici.*

175. Fungus Hæmatodes

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* In this class, Dr. Willan's arrangement of cutaneous diseases is adopted.

176 Aneurisma
177. Varix
178. Ecchymoma
179. Hæmatocele

b. *Adenosi*

180. Scirrhus
181. Carcinoma

c. *Gelatinosi.*

182. Polypus
183. Ganglion
184. Hydatis.

d. *Adiposi.*

185. Sarcoma
186. Encystis

e. *Osteosi.*

187. Exostosis

Order II. Ectopiæ.

188. Hernia
189. Prolapsus.
190. Luxatio

Order III. Dialyses.

191. Vulnus
192. Fractura
193. Ulcus

Order IV. Deformitates

Part V. PRACTICE OF MEDICINE.

We have now gone through four of the great divisions into which we divided our subject; the history of Medicine, Pathology, Therapeutics, and Nosology. We proceed, in the last place, to give an account of the Practice, or the method of applying remedies for the cure of individual diseases. This is the great object towards which all our attention must be ultimately directed, and to which we must apply all the information that we acquire respecting the structure of the body, the operation of its own powers and functions, and that of the various external agents to which it is exposed. Although the practical part of medicine is strictly a science of observation, and one in which we are perhaps less able to predict the result of new combinations of circumstances than in any other department of natural knowledge, yet we are not on this account to discard all attention to general principles, or to reduce it to the state of a mere collection of facts, without endeavouring to obtain some basis of theory on which they may rest, or to which they may be referred. The degree in which we are to allow ourselves to be influenced by general principles, or the share which is to be respectively assigned to theory and to experience, has long been a subject of controversy. As we have seen, in our historical sketch, it gave rise to two of the most celebrated sects of antiquity, and, although not formally recognized in modern times, they may be considered as still having an actual existence. During the period which we have marked out as the 4th epoch in medicine, that which commenced after the revival of letters, and continued until about the middle of the last century, the dogmatic method of studying medicine was generally pursued. Every author of eminence began by laying down a set of general principles, constituting a theory, to which he adapted all his facts and observations, and by the extension of which he attempted to increase his knowledge of the nature of disease, and the means of removing it. When we reflect upon the little success which, for the most part, attended this plan of proceeding, the absolute futility of most of the systems that were formed, the degree in which facts were warped to accommodate them to theory, and the little progress that was actually made in medical science, compared to the quantity of volumes that were written upon the subject, we cannot be surprised that the dogmatic system fell into discredit, and that the method of applying simple observations and experience to medicine, as it had been done to the other sciences, was hailed by the candid and judicious physician as the most auspicious æra in the revolutions of his art. That this change was highly beneficial no one will probably attempt to deny; it directly led to the discovery of many new and valuable truths; and, what was perhaps scarcely less important, it caused the downfal of an accumulated mass of errors and prejudices, which had for ages been received with implicit confidence, and were sanctioned by a blind veneration for the ancients, which proscribed all attempts at improvement as dangerous innovations. We conceive, however, that we have now fallen into the opposite extreme, and have committed an error of considerable, although not of equal magnitude, in endeavouring to satisfy ourselves with the mere result of experience, in indiscriminately discarding theory, and in rejecting the aid of all general principles to connect together insulated facts. We apprehend that an attentive examination of the actual state of medicine will justify us in coming to this conclusion, and that it will be confirmed by the analogy of the other departments of natural knowledge, in which we do not hesitate to admit the advantage which results from a proper union of hypothesis with experiment and observation. There is indeed in medicine an additional reason for uniting the two methods of investigation, that the knowledge which we are able to acquire in this science is less absolute, and is seldom of that decisive nature which can enable us to regard a fact as completely established, without reference to other circumstances, or without considering it as connected with a train of general principles, which form the basis both of our opinions and of our language. The truth of this position will probably be admitted by every one upon due reflection; and, in the subsequent pages, we shall have numerous opportunities of illustrating it, by showing, on the one hand, how extremely difficult it is to establish what may be termed abstract facts in medicine; and, on the other, the great mass of false or imperfect experience, that is daily brought forward by those who profess merely to make and record observations, totally disregarding all the speculations that might be formed respecting the nature or cause of the events which they observe.

Influenced by these considerations we shall not hesitate, in the following pages, to attempt the combination of *a theory of medicine*, with a digest of the practical experience that we possess on the subject, convinced, as we are, that, by this plan of proceeding, we shall both more effectually and more commodiously convey to our readers a knowledge of the present state of medical science. We may farther add, that this method of laying down the general principles of the art is peculiarly proper for a performance like the present, which, it may be expected will be read more by the general student than by the mere practitioner. In pursuance of this idea, and also in consideration of the narrow limits into which we are compelled to include so comprehensive a science, we shall seldom descend to those minute details, which could be essential to a work that was to serve as a manual of practice, and, for the same reason, we shall omit all references to individual cases, or treatises on particular diseases. In some of the preceding parts of this article, especially in the section on Pathology, we endeavoured to lay down the general principles which might serve to form the foundation of a theory of the nature of morbid action in general, or of the powers of the constitution, which tend to restore the healthy condition of the functions. We are now to apply these general principles to the explanation of the nature of individual diseases as they pass under our review. We shall, in each case, attempt to give a characteristic account of their symptoms; we shall examine into the nature of their proximate cause, that change in the state of the system in which they actually consist, or which constitutes their essence; we shall then proceed to inquire into the indications of cure which are respectively adapted to them; and, lastly, we must give an account of the remedies which are to be employed for their removal

In the attempt which we made to arrange diseases on natural principles, we necessarily entered, in some degree, upon the consideration of their primary cause, at least so far as to decide with what part of the animal economy they are each of them more immediately connected, or on the derangement of what function they principally depend. These considerations, connected with the views which we had previously taken of the general doctrines of pathology, led us to propose a classification of diseases according to the different systems which they are supposed primarily to affect, and of these we pointed out the systems of the blood-vessels, the nerves, and those of the nutritive and secretory organs, as composing four classes of diseases, sufficiently distinct from each other, both as far as respects their supposed primary seat, the symptoms which they exhibit, and the means to be adopted for their removal. To these were added three other classes, one of mental diseases, the nature and symptoms of which were conceived to be so peculiar and specific, as not to admit of being placed in any other of our great divisions; *2dly*, a class of structural diseases, where, so far as we are able to judge, the morbid affection originates in, or commences by, a change in the actual structure of some part or organ, as well as in an altered condition of its powers or functions; and, in the *3d* place, diseases that are produced by mechanical injury, producing a displacement of parts or a loss of substance. This mode of arrangement, which we adopted because it appeared to throw some light upon the nature of the diseases, by pointing out their connexion with each other, will form the basis of the method which we shall adopt in considering their treatment. So far as our nosology is founded upon correct principles and deduced from a just and comprehensive view of the pathological relations of the animal economy, it will assist us in our future investigations, while, at the same time, the two subjects will naturally illustrate each other. Our conjectures respecting the causes of diseases will throw some light upon the action of remedies on them, while our experience in this respect must necessarily serve as the most correct and certain foundation for our pathological speculations.

CHAP. I.

Parhæmasiæ, or primary diseases of the sanguiferous System.

We have already remarked upon the connexion which subsists between the different functions and powers of the animal economy, so that it is impossible for any one of the subordinate systems, which compose the whole frame, to be much affected, without communicating a degree of derangement to all the rest. At the same time it is equally obvious, that the actions of the respective systems are neither proportionate in different individuals, nor even in the same individual at different times, forming, in the first instance, those peculiarities, which we style specific constitutions or temperaments, and in the latter, provided the disproportion be sufficiently considerable, constituting diseases of various kinds. As the different organs of the animal body, and the powers which they possess, are in almost every instance differently affected by the external circumstances in which they are placed, we may perhaps be warranted in stating, that disease always depends upon, or is connected with, some disproportion between the actions of the subordinate systems. If we could suppose these actions all to bear the same relation to each other, how much soever they might be increased or diminished in their actual degree, still disease would not be produced. There might, indeed, on the one hand, be a state of great excitement of all the organs, giving rise to a condition of the body which would be unfavourable to health, and might lay the foundation for specific derangement; or, on the other hand, there might be a degree of langour and debility in the performance of the functions, which would prove highly distressing, and ultimately productive of serious effects, but still these could not properly be considered as disease, so long as all the organs maintained their relative connexion with each other, and corresponded in the increase or diminution of their energy.

Of the four different systems which form the main springs of the animal machine, we are induced, from a variety of considerations, to regard that of the heart and blood-vessels as the primary one, as that which is first called into action, which is the most general in its operation, and the derangements of which are felt the most sensibly through all the rest. The primary affections of the sanguiferous system we therefore make our first class, under the title of Parhæmasiæ. From the nature of this system, and from its more direct connexion with the other parts of the animal frame, we have divided the Parhæmasiæ into three orders, the first containing those diseases which essentially consist in an altered action of the heart and arteries alone; the second, those where the nervous system appears to be likewise essentially affected; and the third, those diseases which seem to depend upon some change in the quantity or the distribution of the blood, without any primary alteration in the action of the vessels. To these three orders the names of Phlogismi, Pyrexiæ, and Hæmorrhagiæ, are respectively applied.

SECT. I. *Phlogismi, or General Inflammatory Diseases.*

The Phlogismi are those diseases in which we conceive there to be a derangement in the action of the sanguiferous system, not necessarily connected with any affections of the other systems or functions. Although we might suppose that the sanguiferous system would have been as liable to have its action morbidly diminished as morbidly increased, yet in fact this does not appear to be the case, for it would seem that, in all those instances where the action of the heart and arteries is defective, the primary operation has been upon the nervous system. This circumstance may perhaps be explained upon the principle to which we have alluded above, that a state of disease is never produced unless there be a want of correspondence between the different parts of the animal economy. The heart and arteries being, as it were, the regulators of the whole machine, any change in their state produces a corresponding change in every part of it; if their powers be repressed, those of the nerves experience a similar and proportionate depression, so that, although the body may be rendered weak and inactive, we have no specific disease induced. The same circumstance may indeed occur under an opposite state of things, the increased energy of the sanguiferous system; but this condition, although not necessarily morbid, is, from obvious causes, very liable to become so. When the vessels are acting with unusual force, local derangement in their minute vessels is very easily produced, and irregularity in the functions of the brain and nerves is much more apt to occur from an excess than from a defect of power in the arteries, which supply them with their means of growth and subsistence. Hence the popular notion, that there is a state of high health and vigour, which borders upon disease, and frequently proves to be its precursor, appears to be not altogether without foundation; and, as we advance in the examination of individual diseases, we shall meet with several of them, which, as far as we can judge, originate from an action or a condition of parts, which differs from that of health merely in its excessive degree.

The first genus of the Phlogismi we allot to idiopathic inflammatory fever, which we have named Cauma. Although nosologists have admitted idiopathic inflammatory fever into their systems, yet its existence has been questioned, or even absolutely denied, by many practical writers of the most extensive experience. It seems therefore that it must be an affection of very rare occurrence; and we acknowledge that we never witnessed a decisive and well marked case of the kind. We have, notwithstanding, retained it in our system, because we conceive that in some situations and circumstances it is at least a possible occurrence, and still more, because it frequently exists as a sympathetic or consequential disease, in connexion with various local affections, when it sometimes becomes the principal object of our treatment, and even claims our attention in a greater degree than the primary disease itself. It might be a curious and not uninteresting subject of inquiry, whether there was any disease among the ancients, to which the term of idiopathic inflammatory fever was strictly applicable. We know that a difference of climate, and of the modes and habits of life, produces a corresponding difference in the phenomena of disease; we observe in our own country a more or less inflammatory tendency in the different classes of its inhabitants, according to their residence and occupations, whether they are engaged in the labours of agriculture, exposed to the inclemencies of the seasons, and partaking of a plain and often scanty diet, or confined to the sedentary employments of crowded cities, inhaling their impure atmosphere, and sharing in their luxury and intemperance. It must be admitted that the ancients were generally placed in situations which would render them more liable to inflammatory affections than to those of an opposite tendency; and even in modern times we have occasionally epidemic fevers, which exhibit so much of an inflammatory appearance, as to have induced Cullen and most of our systematic writers to admit the existence of a mixed or hybrid disease, exhibiting in its commencement the symptoms of inflammation, but, as it proceeds in its course, gradually assuming what has been termed, in opposition to this, the typhous type. We think it may be farther questioned, whether some of the fevers, which we regard as sympathetic, are not in reality idiopathic, and whether the local affection is not rather the consequence of a previous state of general febrile excitement, which, according to the idea that has been suggested above, can scarcely exist for any length of time, or proceed to any considerable degree, without settling upon some organ, or acting upon some structure more than the rest; and thus, unless the medical attendant has observed the whole progress of the affection from its earliest commencement, will lead him to conceive that this local affection was the cause and not the effect of the general one.

Although there is no morbid state of the system with which we are more familiar than fever, and where the symptoms are more obvious and prominent, yet it is a disease which it is extremely difficult to define. It varies so much under different circumstances and in different cases, its phenomena are influenced so much by externel causes, and by the peculiarities attached to the individual, that there is scarcely a single symptom which we can point out as characteristic of the disease, or as forming one of its pathognomonic signs, which is not occasionally wanting, or where perhaps even the opposite condition may not be observed. The most general and invariable indications of fever, are increased quickness of the pulse, and increased heat of the body. But these are not always present: the pulse is sometimes unusually slow; and there are certain stages of fever, or even some fevers through all their stages, where the temperature is rather diminished than augmented. If, however, we conceive of an acute and well-marked state of fever, consisting of those symptoms which characterize it in its most general form, we may define it to be, a disease which essentially depends upon an altered condition of the pulse and the temperature, accompanied by a disturbance of many of the functions, by uneasy sensations in various parts of the body, and by a diminution of the vital powers.

The proximate cause of fever has been one of the most fertile sources of medical speculation; and according to the prevaling doctrines in pathology, different theories of fever have been produced, which have acquired importance, not so much from their own merits, as from the powerful influence which they have had on the treatment of the disease. It would carry us far beyond the limits prescribed to this article to examine all these theories in detail; it may be sufficient to state, that while the doctrines of the humoral pathology were received, fever was ascribed to a crude or imperfectly concocted state of the fluids; it was supposed that the efforts of the constitution were directed to expel this noxious matter by some critical discharge, and that the object of the practitioner was, to co-operate with the efforts of nature in the production of this crisis. To this theory, which, under different forms, may be considered as having prevailed until the middle of the last century, succeeded the elaborate hypothesis of spasm, as laid down by Hoffmann and Cullen; this was discarded in favour of the Brunonian doctrine of debility, which has, in its turn, given rise to more recent opinions, some of an almost directly opposite tendency. Of these, one of the most matured and the most plausible, is the doctrine, that the essence of fever consists in a certain species of inflammation: but this idea was never generally adopted; it was confined to a few writers in this country, and even here has been nearly superseded by a still later hypothesis of the proximate cause of fever, that it essentially consists in an irregular distribution of the contents of the blood-vessels, so as to constitute what has been termed a state of congestion in some part of the sanguiferous system.

This mutability of opinion has, no doubt, in a great measure originated from the imperfect state of our pathology, and from the false notions which were entertained on the various topics of natural philosophy in general, as well as from the injudicious application of it to the phenomena of vitality. We conceive, however, that these errors have, in part, arisen from too great a desire to generalize, from a wish to reduce to one class actions which originate from different causes, and depend upon the derangement of different parts of the animal economy. No expression can be more vague than the popular one of fever, and the technical terms which are equivalent to it, such as Pyrexia, or Febris, are scarcely less so. These affections may all indeed be properly placed in the same primary division of a system of nosology, because we conceive that they all depend upon the deranged action of some part of the sanguiferous system; but beyond this we doubt whether there be a single circumstance necessarily common to the whole of them.

It has been the general plan with writers on fever, to regard the paroxysm of an intermittent as a type or model of fever abstractedly considered; and they have always taken for granted, that if any febrile disease which came before them differed materially from this paroxysm, it was owing to some cause interfering with its regular progress, or disguising its real nature. In the fully formed tertian there are obviously three distinct sets of operations or stages, which always proceed in the same order, and appear to bear to each other the relation of cause and effect. The disease commences by the cold stage, in which there is an appearance of diminished action, not only of the blood-vessels, but of every part of the system; this, after a certain period, is succeeded by the hot stage, of which an increased action in the vessels forms the most prominent feature, and the whole terminates by the stage of perspiration, which seems to be the crisis of the complaint, restoring the balance of the circulation, and bringing back the system into its ordinary condition. In viewing this succession of phenomena, we are impressed with the ideas that the primary cause of the paroxysm is something of a sedative nature, that this sedative operation in some way produces a state of increased action, and that the cutaneous discharge which terminates the disease, is a necessary step in the series to restore the circulation to its healthy condition. As these successive events appear to be necessarily connected together, we are almost unavoidably led to speculate upon the nature of their connexion, to show how the sedative operation of the primary cause induces the subsequent reaction, and how this is again relieved by the cutaneous discharge. Provided we confine our speculations within due limits, and do not permit ourselves to be misled by false analogies or by imperfect experience, there cannot be a more legitimate object of research.

We are, however, much disposed to believe, that we have transgressed the bounds of correct deduction, when we have applied the phenomena of intermittent fevers to fevers of other descriptions, and have assumed it as a principle, that they must all of them necessarily consist of the three stages; or that, where any of these stages is wanting, it depends upon some incidental circumstance, and must be regarded as a deviation from the natural order of things. We confess, that we have been led to take a different view of the subject, and to regard the succession of the three stages as not being essential to any form of fever except the intermittent; and, therefore, that the theories which have proceeded upon the idea of their being all of them necessary to compose the complete disease, and of the consequent necessity of assigning a cause for each of them, and of showing how they are necessarily connected, must be fundamentally erroneous. The conclusion which we would draw from these remarks is, that we are not to search for any one proximate cause of fever; that the proximate cause differs in the different species of fever; and that this difference probably depends upon a difference in the predisposing and exciting cause of the disease.

Waving, however, the farther consideration of the proximate cause of fever generally, we shall proceed to describe its symptoms, beginning with those of inflammatory fever, which stands the first in our system. These we shall consider as they occur in their most usual form, when connected with acute local inflammation. Upon this principle, therefore, we are not to regard the description as the account of a mere hypothetical or suppositious disease, but rather as the abstract form of an affection which frequently occurs, although with various modifications and specific differences, which will be noticed when we treat of the different species of the Phlegmasiæ.

Referring to our general definition of febrile diseases, which was given above, we may designate Cauma as a fever characterized by a great increase of temperature, by a frequent and hard pulse, and by marks of unusual excitement in the whole of the sanguiferous system. In offering this definition, we have proceeded upon the principle, that in the proper inflammatory fever there is no cold stage, or that the disease does not commence with a state of diminished energy; but that the exciting cause, whatever it be, immediately produces an increased action of the sanguiferous system, manifested by the state of the pulse, and the temperature of the surface. We are induced, therefore, to regard the exciting cause as directly stimulant, or as producing a directly stimulating effect; and, of course, that the increased excitement, which, in intermittents, constitutes the second stage, and is supposed to be the consequence of the previous state of diminished action, is here the first stage, or the primary operation. In those cases which approached the most nearly to idiopathic Cauma, such as the fever induced by exposure to solar heat, by excessive exercise, or by receiving into the stomach large quantities of distilled spirits, we, in fact, observe no cold stage; and we conceive that, had we not been influenced by a preconceived theory, we should never have supposed, that the operation of these causes would have been different in this instance from what it is in all other cases, where it is obviously stimulating. It may, indeed, be difficult to trace the chain of morbid actions, by which an inflammation in the lungs excites a general sympathetic fever, nor do we pretend to unveil this mystery; but we see nothing, either in the cause or the effect, which should induce us to suppose that the first operation is sedative.

The symptoms of Cauma, whatever idea we may entertain of its nature, or of its cause, are those of excitement in the sanguiferous system. The pulse is increased in force and in frequency; the cutaneous vessels are turgid; while, at the same time, the increased temperature of the surface indicates that they are in powerful action. A remarkable circumstance in the condition of the cutaneous vessels is the diminution of the perspirable matter, as indicated by dryness of the surface; and although it is perhaps not very obvious in what way an increased action of a set of vessels should diminish their natural functions, yet various circumstances in the animal economy lead us to conclude that this is the case. We hence infer, that the same increase of action occurs in all the other capillary vessels; for we observe the same state of imperfect elaboration or defective quantity in their secretions and excretions, and, in some cases, the same dryness and heat in the internal parts as on the surface of the body. Among the excretions, both from its quantity, and from the ready means which we possess of making observations upon it, the urine has always been an object of attention in febrile diseases. Although we are not now in the habit of observing its minute changes with as much nicety as was done in former times, we still consider it as a valuable means of ascertaining the nature of certain diseases, as well as of forming a judgment of their probable event. In inflammatory fever the urine is scanty and high coloured, the latter circumstance being probably the direct effect of the former; thus indicating, that the capillaries of the kidney partake of the same state of excitement with the other minute vessels.

The same state of excitement appears to exist in the minute vessels which belong to the organs of sense. Where we have the most direct means of observing their condition, as in the eye, we perceive the cornea to be rendered turgid by the increased capacity of its arteries, while the increased heat, and the greater sensibility of the organ to the impression of light, are to be referred to the same state of increased activity of the vascular system. It appears, indeed, that this unusual sensibility of the organ depends more upon the greater quantity of arterial blood which is sent to it, than upon any alteration in the state of the nervous power itself; for the cerebral functions are little affected, so that there is seldom any degree of delirium, except in the later stages of the disease, or when it has existed with peculiar violence. Perhaps, were we thoroughly acquainted with all the circumstances, we should find, that in those cases where the functions of the brain have been deranged in Cauma, there has always been some local affection of the brain.

There is one symptom of inflammatory fever which is usually regarded as pathognomonic, the theory of which is, however, obscure; we refer to the state of the blood when drawn from the veins, especially the existence of the yellow crust on the upper surface of the coagulum, forming what has been called the buffy coat. This appearance, which is produced by a certain peculiarity in the coagulation of the fibrine of the blood, so as to permit the red particles to separate from it, however difficult to explain, is to be regarded as an established matter of fact, the connexion of which with a well-marked condition of the system has been correctly ascertained, and which may therefore be employed as a means of directing us both in our diagnosis and in our practice, although we may be entirely ignorant of its proximate cause.

With respect to the exciting causes of Cauma, it will be evident, from what has been said above, that as the disease usually presents itself to us, merely sympathetic of some other affection, it is to be regarded as the effect of this primary disease. We have, however, already suggested, that this idea may have been carried too far, and that there may be some cases in which this latter is rather the effect than the cause. But this is a point of not much practical importance; for, in whatever way the disease may have originated, and whatever relation the local and the general affection may bear to each other, the mode of treatment is the same. This constitutes what has been termed the antiphlogistic plan, and consists primarily in the two points of abstracting from the body a portion of the contents of the vascular system, and in removing all the circumstances which tend to excite the action of the vital powers. The first of these objects is accomplished by various kinds of evacuations, of which the most important are, the detraction of blood, and the operation of purgatives. Bloodletting and purging may be regarded as the most powerful medical agents of which we are in possession. They are of easy application, decisive in their action, and seem immediately to produce the desired effect, without the intervention of any secondary action which may interfere with the primary one. The second object in the treatment of Cauma, the removal of what may tend to excite the vital powers, is to be accomplished by an attention to diet, which must be limited in quantity; and, with respect to its quality, must be of the least stimulating kind. We are to administer cooling drinks, assiduously to afford a regular supply of fresh air, and to avoid all unnecessary exercise both of mind and body. Unless it may be required for the removal of any accidental symptom, there appears to be no internal medicines, except purgatives, which can be considered as essential to the cure of Cauma. Sudorifics were given upon a false theory, and seem, in reality, to have been rather injurious than salutary; and, with respect to the whole class of diluents and refrigerants, there is none equally grateful to the sensations of the patient, or equally efficacious, with some of those domestic preparations, the merits of which depend upon their power of quenching thirst, and of diminishing the excessive temperature of the body. External cold is a remedy, the effect of which is powerful, and in many cases undoubtedly beneficial, yet its use requires considerable caution. Cold air is always grateful, and perhaps never hurtful; but there are certain conditions of the system in inflammatory fever where the application of cold fluids to the whole, or any part of the surface of the body, is scarcely admissible. This obviously depends very much upon the nature of the affection with which the fever is connected, and must therefore be particularly noticed in the remarks which will be made upon the treatment of the different phlegmasiæ. Upon the whole, with the exception of bloodletting and purging, the treatment of Cauma, considered in the abstract, is rather negative than positive, consisting more in diminishing the natural actions of the system, than in attempting to induce any new or altered condition of it.

Sect. II. *Phlegmasiæ; Topical Inflammations attended with Fever.*

Our second genus of the Phlogismi consists of the Phlegmasiæ, or those diseases which originate in the inflammation of some viscus, which is attended with fever. This may be considered as a natural genus, in which it is probable that the diseases all depend upon the same proximate cause, the symptoms being modified by those circumstances that necessarily attach to each part, in consequence of the peculiar nature of its functions, its anatomical structure, or its relative importance in the animal economy. The greatest number of the Phlegmasiæ have their seat in what is termed the viscera; a set of bodies which it is not very easy to characterize by any common properties, except that they consist of a basis of membrane, to which is superadded either secreting or absorbent vessels, nervous matter, muscular fibres or glands, according to the functions which they respectively exercise. Notwithstanding, however, the great diversity in the structure of the parts, there is a considerable similarity in the symptoms which arise from an excessive action of their capillary arteries; a circumstance which affords some reason for supposing that the primary seat of disease is rather in the membranous parenchyma which is common to them all, than in the specific ingredient which belongs to each of them individually. Yet it must be confessed, on the other hand, that mere membranous matter possesses less vitality, or less of the powers which belong to animal life, than many other parts of the system; and that simple membrane, when not forming a part of some viscus, or connected with some specific structure, is not very liable to inflammation, and the inflammation, when it does exist, produces much less general disturbance.

The fever which supervenes in the Phlegmasiæ is of the inflammatory type, of the kind which we denominate Cauma, consisting, from the commencement, of an increased excitement of the sanguiferous system. In addition to the symptoms which indicate the presence of this febrile state, the Phlegmasiæ are characterized by topical pain, corresponding to the part immediately affected, together with an irregular action of its functions; and in consequence of the connexion which subsists between the different parts of the animal machine, it frequently happens, that the derangement of the function, primarily affected, produces some change in another organ, which, although only sympathetic or consequential, is equally uniform, and perhaps more obvious and characteristic than the primary effect. In treating of the various species of the Phlegmasiæ, we shall, for the most part, follow the order of local situation, begining with the head, proceeding to the parts connected with the throat, neck, and chest; and, lastly, to the viscera of the abdomen and the pelvis.

Before, however, we proceed to the description of the Phlegmasiæ, it may be proper to offer a few observations upon topical inflammation. Topical inflammation produces effects which are of so peculiar a nature, and exercise so powerful an action upon the system at large, that many attempts have been made to form a theory of its proximate cause. These theories, like all other speculations in pathology, have been founded either upon fallacious principles, or deduced from some imperfect analogy, so that they have successively fallen into discredit, and have been succeeded by some more novel idea, which was more consonant to the fashionable hypothesis of the day, or attracted attention, as being directly opposed to the one which it was intended to supersede. The humoral pathologists, according to their principles, ascribed inflammation to a morbid state of the blood, and the mechanicians to a want of correspondence between the size of the particles and the diameter of the vessels. The Cullenian theory of inflammation was founded upon the notion of spasm of the capillary arteries; to this succeeded the hypothesis of increased action of the vessels; and lately a directly contrary opinion has been started, that the symptoms of inflammation are best explained upon the supposition that the vital powers of the minute arteries are diminished. We believe that strong objections may be urged against each of these theories; and, upon the whole, we are disposed to think, that we are scarcely yet in possession of a sufficiently correct knowledge of the nature of the powers of the sanguiferous system, to enable us to solve the problem. We shall therefore consider this point as still undecided, and shall satisfy ourselves with assuming the existence of a certain train of events which constitute inflammation, without attempting to explain its proximate cause.

The phenomena of topical inflammation may be briefly characterized by the turgescence of the capillary blood-vessels, accompanied by heat, pain, and redness of the part. These are all the symptoms that are essential to it, when it exists in its ordinary form and its most usual seat, but, as in other cases, its symptoms are considerably modified, both by the degree of its violence, and the part which it affects. As a general principle, it may be stated, that every part of the body is liable to be inflamed, but we find it to occur the most frequently in the parts which partake the most largely of the powers of life, such as the muscular fibre, the skin, the glands, and the secreting membranes. The dense membranes, and even the bones, are, however, by no means exempt from it, although from their mechanical structure, they are necessarily precluded from exhibiting the same symptoms with the softer parts; so that it is rather more from analogy, or from taking into account a variety of accompanying circumstances, than from the actual phenomena, that we judge of this affection of the solid parts. This diversity of structure and of actions, produces a corresponding diversity of treatment, but the general principle is the same, to reduce the quantity of fluid in the inflamed part, and to obviate all causes of excitement.

Sect. III. *Phrenitis; Inflammation of the brain.*

The first species of Phlegmasia that we shall notice is the inflammation of the brain, denominated Phrenitis. Although this disease bears a conspicuous place in all systems of nosology and of practice; yet, in this country at least, its existence as an idiopathic affection is, we conceive, very dubious. Cases are indeed occasionally seen, in which, after a violent inflammatory fever, the brain is found, upon examination, to exhibit marks of increased excitement; but here it may be questioned, whether the fever be not the primary disease, and the state of the brain the effect of some accidental determination of blood to that organ. We have accounts of the state of the brain in hot climates, which appears to be directly induced by the action of the sun's rays upon the head; the vessels of the brain and its membranes are here found to exhibit the most decisive marks of inflammatory action, and we have all the symptoms of cauma, which may be supposed likely to originate from such a local affection. Perhaps these cases ought to be considered rather as examples of the operation of mechanical injury, similar or analogous to the effect of heating substances applied to any other part of the surface, than to the operation of a cause producing an action through the intervention of the vital powers. But, not to dwell upon this question, which may be thought to refer more to a verbal than to an actual difference, we shall proceed to point out the leading characters of phrenitis, without regarding its origin, or inquiring whether it be an idiopathic or a sympathetic affection.

Phrenitis is characterized by acute pain of the head, attended with throbbing of the large arteries; distention of the blood-vessels, as indicated by redness of the face and of the eyes; intolerance of light and of sound; watchfulness or disturbed sleep; paroxysms of violent delirium, accompanied by all the symptoms of acute cauma. We have, in some degree, anticipated our observations upon the causes of phrenitis. Believing it to be almost always sympathetic, we conceive that the supposed exciting causes, such as violent passions, excessive exercise, the immoderate use of ardent spirits, &c. operate by exciting a state of general fever, of which the inflammation of the brain is merely an effect. Many of the causes which have been assigned for phrenitis, such as the cessation of the menstrual discharges, the healing of old ulcers, and other analogous circumstances, which may be supposed to operate by producing some change in the determination of the blood to the different parts of the body, we regard as altogether hypothetical, and without any foundation.

There is an important pathological inquiry respecting the connexion between phrenitis and mania. Inflammation of the brain produces delirium; and the brains of those who have been affected with mental diseases frequently exhibit marks of morbid excitement. Are we then to regard the one affection as the cause of the other? We have little hesitation in replying to this question in the negative. How far any physical change in the brain is essential to mania, or what is the nature of this change, will be considered in a future part of the article; but, so far as respects the present inquiry, it seems very obvious that inflammation of the brain and mental derangement bear no proportion to each other. Indeed, we may go so far as to say, that the distinct appearance of inflammation may often serve as a diagnostic between phrenitis and mania; for whatever theory we may form upon the subject, the symptoms of high excitement in the vessels of the brain, and the violence of the general fever, are sufficient to indicate that the disease is essentially inflammatory, and that the mental affection is only consequential.

Inflammation of the brain, however produced, must always be regarded as a very dangerous disease, and one which requires the most prompt and decisive treatment. Fortunately, however, the plan to be pursued is simple and direct, so that, when its existence is once ascertained, we have only to consider of the extent to which our remedies are to be carried. It consists in the strict antiphlogistic system, in the free use of the various means of depletion, and in carefully abstaining from all means of irritation. Copious blood-letting is the grand remedy upon which we are to depend, in the form of general bleeding from the veins of the arm, opening the jugular vein or the temporal artery, according to the particular circumstances of the case, together with the use of leeches or the scarificator. Each of these methods of discharging the contents of the sanguiferous system have their peculiar advantages; but, as a general principle, it may be stated that the detraction of blood from the veins of the arm, although it may appear a less direct means of relief, is found to be ultimately the most effectual, and is to be chiefly trusted to for the complete removal of the disease. The opening of the temporal artery, or the application of leeches, may be useful, or even necessary, for the removal of pain or other urgent symptoms; but they should never be permitted to supersede general bleeding. It is found that, in this and all other analogous cases of acute inflammation, the manner in which the blood is discharged is of considerable importance, even more than the quantity abstracted; a certain number of ounces, taken away by a large opening, being more efficacious in altering the condition of the system, and subduing the inflammatory diathesis, than even a greater number drawn off slowly through a small opening. Abstinence, perfect rest, and the free evacuation of the bowels, are to be sedulously employed, and become the more important in proportion to the violence of the disease. It may be doubted whether any benefit is to be expected from the external application of cold to the head; but if it prove grateful to the sensations of the patient, there seems to be no objection to its use. Blisters we conceive to be a more doubtful remedy. The irritation which they excite is certainly unfavourable; and it may be questioned, whether it be counteracted by any beneficial effect which they can have upon the contents of the skull, when applied to the surface of the head. Opiates we consider to be inadmissible: they tend rather to increase than to allay the inflammatory state of the system; and when the disease is subdued by other means, sleep is generally procured without their assistance.*

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* The writer is unquestionably correct in his observations concerning the effect of blisters when applied to the scalp in phrenitis. Thus used, they aggravate the excitement in the brain, and increase the determination and quantity of blood to the head. Their operation, however, is as salutary when applied to the wrists and ancles, as detrimental when placed too near the seat of the disease. In phrenitis the tepid bath has in repeated instances been employed with advantage, whereas the clay cap, æther, ice, and other cold applications, have been followed by the most injurious effects, both in the idiopathic and in the symptomatic forms of this disease. HOSACK.

SECT. IV. *Inflammation of the Parts about the Neck and Throat.*

The four next Phlegmasiæ consist in the inflammation of the parts about the neck and throat, of which those that are sufficiently well marked to be regarded as distinct diseases, are parotitis, tonsillitis, laryngitis, and trachitis; the inflammation of the parotid gland, the tonsils, the larynx, and the trachea, respectively. The inflammation of the parotid gland is a disease that occurs chiefly among children. It is epidemic, and appears to be contagious, and to have the property of occurring once only during the life of the individual. These two latter circumstances are supposed to be established as matters of fact, although it is certainly difficult to account for them upon any analogy with other diseases that possess these characters. The symptoms of parotitis are sufficiently obvious, and immediately arise from the enlargement of the part by the distention of its vessels, or effusion into the cellular substance. There is a curious circumstance connected with this complaint, which, like those mentioned above, is proved by numerous observations, that if the tumour of the gland be prematurely repelled, inflammation and swelling of the testes occur. It has been said, but we think upon less decisive authority, that, in the female subject, the repulsion of the tumour produces an analogous affection of the mamma. The complaint generally continues about four days, and is attended with a degree of general fever, but it is seldom so violent as to require any active medical treatment. The mild antiphlogistic plan is the one that we must pursue. We must cautiously guard the part against external cold, in order to prevent the above mentioned metastasis. Should this take place, the testes or the mammæ must become the objects of attention; and in proportion to the importance of these organs, our practice must be prompt and vigorous

Tonsillitis, or inflammation of the tonsils, may be easily detected by the local pain and the difficulty of deglutition, as well as by the inspection of the parts. Unless it be in an advanced stage, these circumstances sufficiently distinguish it from the affection of the throat, to be hereafter described, which exists in scarlatina, and in all well-marked cases, we have a farther means of discrimination, by the nature of the accompanying fever, which, in tonsillitis, is of the inflammatory type. Tonsillitis may also be distinguished from scarlatina by the absence of the cutaneous eruption, which forms a characteristic symptom of the latter, as well as by the exciting cause. This appears to be always exposure to cold; but it is a disease which, when it has once existed in a violent degree, is very liable to recur, from an application of the exciting cause, so slight as almost to escape observation. The fever which accompanies the inflammation of the tonsils, is often considerable; and the affection itself, although it cannot be considered as of a dangerous tendency, becomes, from its connexion with the organs of respiration and deglutition, highly distressing, and requires the active antiphlogistic treatment; the degree to which this is to be carried depending entirely upon the urgency of the symptoms. General bleeding is, perhaps, not often necessary; and as the affection is, in its origin, entirely local, and the part within our reach, we can, with more advantage, substitute topical bleeding, either by leeches from the neck, or what, in very urgent cases, will be more effectual, by scarifying the tonsil itself. Purgatives and low diet are indispensable auxiliaries; and, in certain stages of the complaint, fomentations to the external fauces, and the inhalation of the steams of hot water, along with tepid drinks, are agreeable to the sent sations, and generally useful. Cold air appears not to be admissible; but all attempts to excite perspiration by external warmth, or by hot stimulating medicines, are highly injurious. In febrile affections, which are not of the most acute inflammatory kind, immersing the lower extremities in warm water generally proves a means of allaying irritation, and of procuring sleep; and it may be always had recourse to with advantage in this complaint. We are disposed to think that little or no benefit is to be derived from gargles, while the efforts made to use them are always painful, and perhaps even injurious. Blisters to the external fauces, in urgent cases, may be employed; but as the disease itself is not of long duration, it has sometimes happened, that a crisis has occurred before the blister has been able to take effect, and the patient has suffered more from the remedy than from the disease itself. When the inflammation of the tonsil has been violent, suppuration occasionally takes place in it: when this occurs, which may be ascertained by inspecting the part, or by the sensations of the patient, an artificial vent must be given to the matter, provided it does not quickly discharge itself by a natural opening.

Laryngitis, or the inflammation of the larynx, is a disease of probably not very frequent occurrence; until lately, it was confounded with the inflammation of the trachea, or other neighbouring parts; but it appears to have a separate existence, and, when in an acute state, may be recognized without much difficulty. The diagnosis of laryngitis and trachitis depends upon the situation of the parts concerned; in the former, the deglutition, from the commencement, is extremely painful and difficult, while the respiration is likewise considerably affected; in trachitis, the difficulty of respiration is, from the beginning, the urgent symptom, the power of deglutition being little, if at all, impaired. By inspecting the fauces, it may be distinguished from tonsillitis; for although we may perceive some degree of tumour and inflammation of the tonsils, they are by no means in proportion to the violence of the other symptoms. The exciting cause of the disease is rather obscure; at least if we are to regard it as being induced by the application of external cold, we do not know way, in these cases, the larynx is the part that is particularly affected. By examination after death, the inflammation is found to be chiefly confined to the epiglottis, and the upper part of the larynx. It is very rapid in its progress; and unless it is taken in an early stage, and the most decisive measures are adopted, it generally proves fatal. This event principally depends upon the mechanism of the parts concerned, which, when they are enlarged by inflammation, and covered with a thick mucous secretion, entirely prevent the entrance of air into the lungs. The treatment consists in very copious bleeding, general and local, to which may be added, as auxiliary means, blisters, fomentations, and the inhalation of hot steams; purgatives, and the other parts of the antiphlogistic regimen are, in the mean time, to be assiduously applied. Upon the idea of the local nature of the disease, bronchotomy has been performed, which, by opening a free passage for the admission of air into the lungs, has given immediate relief to the most distressing symptoms. Where the patient is dying from mere suffocation, and his strength is not completely exhausted, the operation may be had recourse to, as the means of averting immediate death, and giving the only chance of relief.

Trachitis, or croup, as it is popularly styled, essentially consists in an inflammation of the trachea; but the affection frequently extends to the neighbouring parts, as to the larynx, the bronchiæ, or even over the whole substance of the lungs. It is one of those diseases, which, from some unaccountable combination of circumstances, seems to have first made its appearance in modern times. It is not mentioned by medical writers until about the middle of the last century, and it is very difficult to conceive that it could have previously existed, without being noticed as a distinct affection. It is almost exclusively confined to children; for those cases of croup which have been described as occurring in adults are probably to be referred to laryngitis, with which, until lately, it was confounded. It would appear, that, from some constitutional peculiarities, the same cause which excites the inflammation of the trachea in children, induces inflammation of the larynx in the adult; while the parts, although in immediate contact, and resembling each other so much in their structure, are seldom both primarily affected at the same time, or in the same degree. The croup has been thought to be contagious, but we think without sufficient evidence. It is endemic in certain situations, probably from their being more exposed to cold and moisture; and it is observed to prevail in some families more than others. A child that has once suffered a severe attack of croup is liable to returns of it from slight causes; but these second attacks are seldom, if ever, so severe as the original one.

Trachitis commences with the symptoms of a feverish cold, characterized by a harsh cough. On the second or third day the breathing becomes much oppressed, the fever increases, the cough becomes violent and shrill, while the respiration is converted into the most painful effort to receive the air into the lungs, accompanied with a peculiar sound which is difficult to describe, depending upon the contraction of the trachea, in consequence of the thickened state of its internal membrane, and the quantity of viscid matter with which it is lined. If very vigorous measures be not immediately resorted to, the passage becomes completely closed, and suffocation speedily ensues. The membrane which lines the trachea is of that class which is styled mucous, and, in its natural state, seems to be similar to the membranes which secrete the same kind of fluid in other parts, yet the symptoms that occur in trachitis are in some measure specific, and the matter which is discharged seems to differ from that which is secreted in other cases; but the cause of this difference is not explained. The disease is very speedy in its progress, and almost always proves fatal, if left to the efforts of the constitution. Indeed we think it may be doubted, whether a spontaneous cure was ever effected when the acute disease was fully formed, and no means had been adopted for its removal.

The treatment of trachitis obviously consists in carrying the antiphlogistic system as far as the strength of the constitution will permit; for it appears, that nothing short of the prostration of the vital powers can effect a solution of the inflammatory state. General bleeding is the means of cure on which we are principally to rely. We are also to draw blood from the neck by leeches, and may afterwards apply blisters to the part. Purgatives are to be freely administered; and it is probable that in this, as in all other similar cases, they will be found most effectual when calomel enters into their composition. When the disease terminates favourably, there has generally been a peculiar expectoration of thick viscid mucus; and we even hear of a substance being discharged, which, from its form, appears as if it was composed of a kind of membranous lining for the trachea. When this occurs, it is to be regarded rather as the consequence than the cause of the cessation of the morbid condition of the parts; but it has induced practitioners to employ various means for procuring this kind of crisis, by administering expectorants and emetics, such as squills, seneka, ipecacuanha, and antimony. We conceive, however, that very little benefit can be gained by these medicines; and considering the tender age of the subjects of the disease, and the rapidity of its progress, it may be doubted, whether we are not interfering with the employment of more active and less equivocal remedies. A plan of treating croup has been lately proposed from high authority; which, instead of the depleting system, trusts the cure entirely to the exhibition of calomel, giving it in frequently repeated doses, until the state of the respiration is relieved. We are scarcely prepared to give a decided opinion upon so important a point of practice; but the conviction derived from our own experience is, that, in urgent cases, the abstraction of blood, and the other means which have been recommended above, are absolutely necessary, and should be had recourse to without the loss of time which would be incurred by making trial of other remedies.*

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* The author does not seem fully acquainted with the nature of trachitis, (commonly called croup, or hives.) nor to have been practically acquainted with its mode of treatment. It is assuredly a most active inflammatory disease; frequently comes on with great suddenness; and, in those instances in which it has been said to be infectious, has doubtless been connected with cynanche maligna or scarlatina. Idiopathic cynanchæ trachealis, we have no reason to suppose to be ever infectious. The writer of the text observes, that he has even *heard* of a substance being discharged, which, from its form, appears as if it was composed of a kind of membranous lining of the trachea. Every one who has been for any time practically conversant with this disorder, must, in our opinion, have witnessed the peculiar membrane formed by it. Dissections have often shown it, and it is often ejected by vomiting. I have been led to distinguish *three* stages in croup: the first may be denominated the *forming* stage. In this the affection is local, the irritation has not extended to the whole system; the child even sits laughing and playing upon the lap of its mother; its skin is cool and moist, its pulse not perceptibly accelerated; but its hoarse, hollow sounding, and frequently returning cough, its wheezing inspiration, its restlessness, and especially its cries after a fit of coughing, all denote the consequences that will ensue, if active means be not employed to prevent the second or *febrile* stage. In this stage the whole system partakes of the irritation; the pulse is frequent, the skin hot and dry, the respiration hurried, the tongue covered with the usual white fur, indicative of inflammation, the lips and cheeks remarkably florid, the cough frequent, but attended with a more acute sound than in the first stage; every inspiration is attended with more uniform wheezing than that which appears in the first, when occasionally an interval occurs in which the child breathes as if in health. But in this second stage no such interval is perceived; the trachea, bronchiæ, and lungs become so surcharged by the circulating fluid, that the child has not even a momentary relief from its oppression; and, in a short time

Sect. V. *Inflammation of the Chest.*

The inflammation of the chest is generally supposed to give rise to two distinct affections, according to the exact seat of the disease, whether it attacks the investing membrane, or the substance of the lungs themselves, the first producing pleuritis, the latter pneumonia. There is reason to believe, that from some cause, which it is not easy to assign, these two parts are not always affected in the same proportion, and that some variation of symptoms arises from this circumstance; but as they both originate from the same cause, are of the same nature, and require the same remedies, and, especially as they frequently exist in combination with each other, we shall not think it necessary to treat of them under separate heads. The disease, in whatever form its exists, is attended with a pain of the side, which, in pleuritis, is generally more acute and more local, with a hard cough, and a difficult and painful state of

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if left to itself, especially if the patient be plethoric, the countenance exhibits a purple livid colour, not unlike that of apoplexy, and is even attended with a degree of stupor, or propensity to sleep. If the patient be now neglected, or the evacuation be sparing and insufficient, &c., effusion from the exhalent vessels opening into the wind pipe, bronchiæ, and surface of the lungs, inevitably take place. In the two former, the effused matter assumes a membranous appearance; but in the lungs themselves it appears in the form of a viscid fluid, partly resembling both phlegm and pus. When this effusion has taken place, the febrile symptoms sensibly abate, and sometimes disappear altogether; the child is also apparently free from pain, but it suffers violent paroxysms of cough and difficult breathing, as in asthma, or dropsy of the chest, and with similar intervals of ease. These paroxysms, in young children, continue but a few hours before dissolution." But in children arrived at eight or ten years of age, they frequently continue several days.

In some cases, the impediment to respiration and the distress attending the paroxysms are so great, that the only position in which the patient can respire is with the head thrown back. In some instances, before death, general convulsions ensue, which speedily terminate the sufferings of the patient. This stage, in which the membranous effusion takes place, I call the *membranous* or *purulent* stage: from this advanced state of the disease recovery is so rare, that it is not to be expected: it might almost be denominated the *fatal* stage of croup. These distinctions lead to important conclusions in practice.

They teach us, during the first or forming stage, to adopt the most active means of restoring the suppressed secretions of the trachea and surface of the lungs, and by open bowels, and by perspiration, to guard against the general excitement of the system For this purpose, it is my practice to administer an emetic composed of tartarized antimony and ipecacuanha. To a child under two years of age, I direct from one to two grains of the emetic tartar, with from five to ten grains of ipecacuanha, every fifteen minutes, until it operates to such a degree as to induce a plentiful secretion from the trachea and lungs. When the emetic has no other effect than to produce vomiting, I immediately direct the bowels to be emptied by the common injection, and a dose of calomel, from five to ten grains, to be given, unless the child may be completely relieved.

If febrile symptoms have already manifested themselves, other remedies are indicated. In this second stage of croup, such is the determination of the circulating fluids to the part affected, and such the general febrile excitement, that the most efficient means of diminishing the plethora of the blood-vessels, and of diverting the irritation from the part affected, become necessary. With this view the patient should be bled freely; say for a child under two years, from two to four ounces; from two to six years, from four to six or eight ounces, and to be repeated as the urgency of the symptoms may require. Most writers recommend the blood to be taken from the jugular veins. As I have never, even in the youngest children, experienced any difficulty in opening a vein upon the back of the hand, and of drawing a sufficient quantity of blood from that part, especially after immersing the hand a short time in warm water, I have never had occasion to open a vein in the neck. After blood-letting, some partial relief is immediately obtained; respiration is less frequent, the peculiar noise is also diminished; the cough becomes more loose and yielding; the skin is rendered moist, and the pulse less tense and frequent. But these favourable symptoms are often deceptive, and of short duration: the cough, laboured respiration, and heat of skin, are perhaps all renewed in the course of an hour. In such case the antimonial emetic must be immediately employed. Although the force of the disorder may have been greatly subdued by blood-letting, the alarming symptoms so frequently return, that I am now in the constant practice of prescribing the emetic immediately after blood-letting, without waiting to ascertain the effects which the bleeding alone might produce: if, however, after the operation of the emetic, the symptoms still continue violent, I usually repeat the bleeding, immerse the patient in a warm bath, apply a large blister to the throat, and administer a cathartic of calomel, repeating this medicine every two hours, until it produces some sensible effect in this respect, at the same time soliciting its operation upon the bowels by injections.

These several remedies having been employed, and having failed completely to subdue the febrile symptoms, and to divert the irritation from the trachea and lungs, I next direct small doses of calomel and James's powder, from two to five grains of each, to be given every two hours to a child under four years of age; sometimes I substitute the antimonial wine, or a solution of tartar emetic, blended with a small portion of laudanum, where it may be indicated. In the *third* stage, the respiration is still laborious, the cough is still violent, without the least expectoration, and returns in paroxysms: the countenance exhibits a bluish livid colour; occasionally the patient has intervals of ease; but these intervals are of short duration, and afford no prospect of relief, for the effusion and the consequent formation of a membranous matter has already taken place. In this stage, it has happened that portions of the membrane have been thrown off by coughing, by which the patient has been preserved.

Calomel, squills, the syrup of onions, the seneka snake-root, ammoniac, and asafœtida, and the vapour of vinegar and water, are the medicines upon which I am now inclined to place most reliance. A case related by Dr. Rush, of the good effects of calomel in the advanced stage of croup, should incite us to the diligent use of this remedy, even after the effusion of the matter constituting the membrane has been ascertained to have taken place.

Dr. Archer has rendered an important service to medicine, by introducing into general use the polygala seneka as a remedy in croup; though it has certainly disappointed the expectations of most practitioners, because it has been prescribed indiscriminately in every stage. Whereas, for the very reason that it is so useful in the last stage, it is hazardous in the forming and febrile stages, when the vessels of the trachea and lungs are preternaturally excited. If circumstances, however, should indicate an emetic in the last stage, and the decoction of seneka should prove insufficient, the sulphate of zinc or copper is certainly preferable to that of antimony or ipecacuanha, the former being less debilitating, while they afford all the advantages which can be obtained from the mechanical operation of vomiting:—a cup of sago, arrow-root, chicken soup, or weak wine whey, is also now of use to sustain the strength of the sufferer.

In a case of idiopathic croup, which fell within the practice of Dr. Francis of this city, upon the afternoon of the third day of the disease the salutary operation of the vitriolic emetics was happily manifested, even under the most discouraging circumstances. The patient was a female child about two years of age; through neglect, the disorder had uninterruptedly run its course, and had advanced to what I have termed the third stage. Little or no hopes being entertained of its recovery, a strong solution of the sulphate of zinc, and afterwards of the sulphate of copper, were freely and repeatedly given, and the excitement of the system roused by blisters, a stimulating warm bath, and enemata. These means were persisted in by Dr. F for twenty-four hours, when the membrane was finally detached in pieces, and thrown up by vomiting, after which the patient was rapidly restored.

Though little doubt can exist, that croup has been sometimes confounded with laryngitis, yet we have evidence sufficient, that adults are occasionally affected by it. The importance of this disease, arising from its great frequency in this country, and the alarming fatality which so often follows it, must plead as an apology for the length of this note.

Hosack.

the breathing, much aggravated by an attempt to make a full inspiration, attended by an acute cauma, as indicated by the condition of the pulse and the blood, and by all those circumstances which originate from an increased excitement of the sanguiferous vessels.

The exciting cause of the disease seems to be, always exposure to wet and cold, more especially, as it would appear, when applied to the feet. A patient who has once suffered from a severe attack of the complaint is always subject to a recurrence of it; and, unlike what we observe with respect to trachitis, the second attack is often more violent than the first, and the lungs are often so much affected as never to regain their ordinary healthy state. It is commonly said by systematic writers, that persons of a robust habit are most subject to inflammation of the lungs, but this we suspect to be an erroneous opinion, derived from a false hypothesis of the nature of inflammation. The danger of the disease depends upon its violence, and the previous constitution of the patient.

As in none of the Phlegmasiæ the fever exhibits a more decided inflammatory type, so the treatment must be proportionally vigorous. Large and repeated bleeding from a free orifice, is the grand remedy on which we are to depend, and, under favourable circumstances, generally proves successful; but it not unfrequently happens, where the disease has been neglected in its earlier stages, or the constitution is naturally feeble, that the patient cannot bear those means which seem to be essential for the removal of the complaint. Besides bleeding, we are to employ blisters, purgatives, and all the other parts of the strict antiphlogistic system, except the application of cold, which, although it has been recommended by some writers, we are not prepared to admit. In some cases, after very large bleedings have been employed, so as to reduce the strength of the patient to the lowest pitch which seems to be consistent with safety, the complaint still remains unsubdued; the pain, cough, and difficulty of breathing continue, while the pulse, although small, still gives the sensation of tension and hardness. Under these circumstances, digitalis has lately been recommended; and we think it a fair subject for trial, although we suspect that the grounds of its recommendation have been rather theoretical than practical. When the disease assumes a favourable aspect, an expectoration of mucus is generally one of the first changes that we observe to take place, and, on this account, it has been generally the custom to exhibit a variety of medicines to produce this effect. But, as we observed above, we conceive that this proceeding has arisen from mistaking the effect for the cause; and as the operation of expectorants is essentially stimulating, we are of opinion that they must, in such cases, prove positively injurious. The same conclusion we should form respecting the use of nitre, which is generally prescribed in this complaint, from some unaccountable conception of its being refrigerant. In the latter stages, where the cough remains after the fever is subdued, the same remedies may be found serviceable, as from cough arising from any other cause, and the irritation which is then left in the system, reduced as it is by previous depletion, may require small doses of opium, especially in that most useful combination with ipecacuanha, called Dover's powder. When the disease terminates unfavourably, it is either from the immediate effect of suffocation, or less directly by the formation of purulent matter, which induces a hetic fever, and eventually proves fatal, although perhaps not until after a considerable lapse of time. When the matter is effused into the cavity of the thorax, it has been proposed to give vent to it by an artificial opening between the ribs; and cases are upon record, where this operation is said to have been performed with permanent relief to the patient; but even if we admit the accuracy of these statements, the prognosis must be considered as extremely doubtful. The pleura is one of those membranes styled serous, which, when they become the subject of acute inflammation, are disposed to throw out an exudation of what appears to consist essentially of the fibrine of the blood. This substance, under certain circumstances, becomes an organized body, and if two inflamed surfaces are in contact with each other, adhesion takes place between them, an occurrence which frequently happens in the cavity of the thorax.

One of the consequences of pneumonia, which is much to be dreaded in certain constitutions, is the formation of what have been called tubercles in the lungs, which are a very frequent, if not the only proximate cause of that fatal disease, Phthisis Pulmonalis. As the inflammation of the chest is extremely liable to recur, and is more dangerous in its second attacks, from the weakened state of the patient, and from the condition of the organs being less able to bear the violent excitement, which constitutes the proximate cause, it is particularly necessary, during convalescences, and even for some time after the health appears to be restored, to adhere most strictly to the antiphlogistic regimen.

Before we proceed to the inflammation of the abdominal viscera, we must make a few observations upon the inflammation of the heart, or Carditis. This is a disease which is not very frequently the direct subject of medical practice, partly, as it would appear, from its being of comparatively rare occurrence, but in some measure, also, from its symptoms being equivocal and difficult to recognize; for we occasionally discover, after death, the evidence of violent inflammation having existed in the heart, when no symptoms had previously occurred to indicate its presence. It is not a little remarkable that, in these instances, the pulse has not been much affected, even less so than from the same degrees of inflammation in a part of equal magnitude, which is less immediately connected with the circulation. The difficulty of diagnosis in these cases is, however, of comparatively little importance in a practical point of view, for the treatment coincides, in every respect, with that of the inflammation of the other thoracic viscera.

SECT. VI. *Inflammation of the Abdominal Viscera.*

All pathologists and systematic writers, in describing inflammatory affections, speak of them as existing under two forms or states, which are denominated acute and chronic. These terms strictly refer either to the violence of the symptoms, or to the length of their duration; but the two species of inflammation seem to have an essential difference, more than what depends upon mere degrees. The varieties of acute and chronic inflammation are peculiarly well marked in the affections of the liver; the first consisting of those symptoms which might be supposed to originate from an excitement of the sanguiferous vessels of the part, pain and enlargement of the right hopochondrium, with an acute inflammatory fever; while, in the chronic variety, there is much less pain, the swelling comes on gradually, the fever is less violent in its attack, and all the symptoms are less rapid in their progress. In the acute disease the functions of the part seem at first to be but little affected, and only to suffer in consequence of the disorganization or absolute destruction of a portion of the liver, while, in the latter, some of the first symptoms that we experience are, an irregularity in the biliary secretion, producing jaundice, and particularly affecting the stomach and the bowels. These varieties seem to differ in their cause as well as in their symptoms; the acute state is produced by all those circumstances which induce inflammation of other parts, such as exposure to cold, external injuries, violent exercise; while the chronic is generally the effect of a residence in warm climates, or the intemperate use of spiritous liquors. The two varieties, however, although often sufficiently distinct, are not unfrequently combined together, or succeeded one by the other; and some of the exciting causes seem to be capable of generating either of them, according to the degree in which they are applied. This is particularly the case with respect to the use of ardent spirits; and we also observe that external heat, which generally produces the chronic species, occasionally gives rise to an acute affection. The proximate cause of the latter variety, or the mode in which it is excited by exposure to a high temperature, is not fully explained, although it seems reasonable to conclude, that it depends upon some changes which the bile undergoes in these cases; but the farther consideration of this point we must refer to our article PHYSIOLOGY. With respect to the actual difference between these two varieties, we think it not improbable that it may depend upon a difference in the part of the organ which is primarily affected; the first depending upon an inflammation of the membrane of the liver, while the latter consists of an affection of the glandular parts which secrete the bile. There are two symptoms in Hepatitis which may be regarded as pathognomonic, a difficulty in lying down on the left side, and a pain in the right shoulder; the latter of which it is difficult to account for upon any principles either of anatomy or pathology. The acute variety not unfrequently terminates in suppuration; and although there are some remarkable cases, where very large abscesses have existed with much less disturbance of the general health than might have been expected, still the result is almost always ultimately fatal. A few fortunate instances are indeed upon record, where the abscess has burst externally, or into the intestines, and where the cavity has closed, so that the patient has regained his usual state of health; but these must be regarded as very unexpected events. The termination of chronic hepatitis is a scirrhus of the liver, that state of the organ where it becomes enlarged and hardened, as it appears from a primary affection of the secretory vessels: this is not attended with any violent pain or acute symptoms, but the functions of the part are gradually destroyed, and the constitution ultimately sinks, in consequence of the various derangements that necessarily ensue.

The treatment of the two varieties of Hepatitis differs considerably according to their symptoms, and the supposed difference of their nature. In the acute kind, the antiphlogistic system, in all its parts, must be strictly pursued; copious, general, and topical bleeding, blisters, and purgatives, form the essential part of the treatment; while, in the chronic kind, although depletion to a certain extent is necessary, the chief reliance is generally placed upon mercury. The way in which mercury acts in those complaints which consist in, or are accompanied by an indurated condition of the secretory glands, we are not prepared to explain, but its beneficial effect is generally admitted; and although it is a remedy which is peculiarly apt to be abused, and which not unfrequently produces effects more to be dreaded than the disease itself, yet no reasonable doubt can be entertained of its utility, when properly administered. Besides the removal of the diseased condition of the liver, the stomach and bowels require particular attention in the chronic variety; for the former the exhibition of tonics and bitters may be necessary, and for the latter purgatives are clearly indicated; but on these points it is difficult to lay down any general rules. We may remark, that it is obviously desirable to avoid all those medicines which are of a heating or stimulating nature, and to trust the cure in a great measure to purgatives, combined with the requisite quantity of mercury.

One of the novelties in medical practice, is the introduction of nitric acid into the materia medica as a remedy for diseases in the liver. Its beneficial effects are stated to be equally evident, whether it be received into the stomach, or applied externally in the form of a bath for the lower extremities, when properly diluted with water, a statement which is not a little remarkable, and which must excite considerable scepticism. We are not able, from our own experience, to give an opinion of its effects in either of these forms, but we may remark, concerning them, that if the external use of the acid produces all the good effects that have been ascribed to it, it presents a singular anomaly, which is not to be reconciled to any of the known operations of the animal economy. The state of the system which is left, after a residence in warm climates, is much relieved by the use of the saline mineral waters, such as those of Cheltenham.

The inflammation of the stomach and intestines, named respectively gastritis and enteritis, as they consist in an analogous affection of parts possessing nearly a similar structure, which bear a strong resemblance to each other, and differ merely in those circumstances which are immediately connected with their specific functions. Gastritis seldom occurs as an idiopathic affection, but it is not unfrequently produced by the reception of certain substances into the stomach, as chemical acids, large quantities of ardent spirits, and perhaps even by mere repletion. The effect of cold fluids taken into the stomach, and of blows upon the part, are probably to be referred to a different proximate cause, although they have been enumerated among the exciting causes of gastritis. Inflammation of the stomach is characterized by an acute pain of the part, with a sensation of heat and distention, attended with extremely severe vomiting, burning thirst, and perpetual restlessness; the degree of accompanying fever is always considerable, and it is of the inflammatory type, but it differs from the other forms of Cauma in the state of the pulse, which, although hard and quick, is small and contracted, indicating that the vessels are in strong action, but that the stream of blood is small. The progress of the complaint is very rapid, speedily terminating in a state of complete exhaustion, and the prognosis is extremely unfavourable; its termination appears to be always in gangrene or the immediate death of the part, without the precursory stage of suppuration. This is indicated by the sudden cessation of pain, so as to afford the patient a fallacious expectation of the removal of the disease; but this apparent amendment is soon followed by the sinking of all the vital powers, and by speedy dissolution.

It is scarcely necessary to observe, that, if the inflammation of the stomach be excited by any chemical acrid received into it, those substances are to be employed which possess the power of neutralizing its irritating properties, so long indeed as we suspect that any portion of it is still left in the body. In most cases, however, it is probable that the substance is quickly expelled by vomiting, and that the fatal event which ensues depends rather upon a proper inflammation excited in the stomach, than upon any erosion or direct chemical action of the part; and we are of course to depend more upon the remedies for removing or remedying general inflammation, than upon any means that we can adopt for counteracting the topical operation of the substance.

The symptoms of enteritis are essentially the same with those of gastritis; the pain is more acute; the abdomen is distended, and tender to the touch; there is severe vomiting, and at the same time the bowels are obstinately constipated. The nature of the fever is the same, and there is the same peculiarity in the state of the pulse; the termination of the disease is equally fatal, and it is always preceded by a remission of pain, and of the constipation of the bowels; but the condition of the pulse, and the sinking of all the vital powers, indicate that this flattering appearance of relief is only a prelude to dissolution. It is sometimes of importance to be able to form a diagnosis between enteritis and colica, diseases which agree in many of their leading symptoms; the pain of the part, the vomiting, and the constipation: but the state of the system with respect to general fever, is the circumstance from which we are to derive the distinctive characters of the two diseases; and it is, in most cases, sufficient for this purpose. It may, however, be remarked, that although the diseases are probably quite different in their origin, they become connected in their progress, or rather the proximate cause of colic has a great tendency to produce inflammation in the bowels, which in no respect differs from enteritis in whatever way produced. The cause of the peculiar state of the pulse in inflammation of the stomach and bowels, does not appear to be explained; but it is a well-established matter of fact, and it is very important for the practitioner not to be deceived by the smallness of the artery, which by an unexperienced person might be mistaken for a state of debility, and who might therefore be prevented from having recourse to the full depleting system, which alone can be of any essential use in the removal of the complaint.

There are no diseases in which blood-letting, both general and local, are more efficacious than in gastritis and enteritis; and indeed, in the former of them, it is the only one upon which any considerable confidence is to be placed, for the state of the stomach will not admit of the use of internal remedies; and it may be doubted whether the rapid progress of the disease will afford sufficient time for any benefit to be derived from blisters. In enteritis it is of great importance to procure a free evacuation from the bowels, and this is equally the case whether the inflammation be idiopathic or be symptomatic of colic; indeed in this last case it is probable that the constipation is itself the exciting cause of the inflammation. Unfortunately this is an object which it is very difficult to effect, nor are we able to determine what is the best method of attempting to accomplish it The administration of purgatives is generally precluded by the state of the stomach; and even if they are not rejected by vomiting, it may be questioned whether their action on the bowels would not rather tend to aggravate that condition of the parts which constitute the proximate cause of the disease. Purgative glisters, although not without their use, can scarcely be regarded as more than palliatives. Small, and frequently repeated, doses of calomel, have sometimes been retained upon the stomach, and have effected the relaxation of the bowels in cases where no other medicines could be employed; and injections of the infusion of tobacco are reported to have accomplished the same object. In circumstances of peculiar urgency such remedies may be properly had recourse to; but we conceive that both of them, especially the latter, are to be regarded rather as admissible, when other means of relief have failed, than as what is to be employed as an established practice. Against tobacco there lies the objection that it is extremely apt to increase the tendency to vomiting, and that in the feeble state of the system which occurs in the later stages of enteritis, there may be some danger of its suddenly extinguishing the vital powers in consequence of its powerful narcotic effects. Upon the whole, we are disposed to think that the most prudent plan is to place almost entire reliance upon those means which are calculated to remove the general inflammatory action, when it will commonly be found that the constipation of the intestines will either yield spontaneously, or be removed by the exhibition of comparatively mild purgatives and injections. Blisters to the abdomen, fomentations, and the warm bath, are recommended in enteritis, and occasionally found to be useful; but sometimes the trouble attending their exhibition appears to be greater than the benefit derived from them, and they must never be relied on to the exclusion of more active remedies. From some hypothetical opinion of its relieving spasm, opium has been employed in this disease, but, as we apprehend, with decidedly injurious effects; nor indeed do we think that there is any internal medicine, besides purgatives, which can be of essential benefit, except where the disease exists in a slight degree, or when its violence has been removed by more appropriate means.

It has been customary with systematic writers to divide these inflammatory affections into the two varieties of erysipelatous and phlegmonic, corresponding to the similar kind of affections which occur on the surface of the body, but we doubt much of the reality of the distinction, or the correctness of the pathology which gave rise to it, nor indeed, if they actually exist, do we think that we have any diagnostic symptoms by which they can be recognized.

SECT. VII. *Puerperal Fever.*

The other abdominal viscera, as the kidney and the spleen, as well as the peritoneal membrane, together with the viscera of the pelvis, the bladder, and the uterus, are occasionally the subject of inflammation, and are characterized by their appropriate symptoms; but as they are of comparatively rare occurrence, are generally connected with some other affection of the organs, and are to be treated upon the same principles, we shall not enter into any particular account of them. There is, however, one affection, which, from its violence, and from some peculiarities in its nature and symptoms, deserves to be especially noticed, the puerperal fever.

This is a disease which occurs to women in the puerperal state: it consists of great pain and tenderness of the abdomen, attended with an acute fever, characterized by great quickness of the pulse, heat of the body, some degree of affection of the mental faculties, suppression of the secretion of the mammæ and of the uterine discharge, and passing with unusual rapidity to a state of excessive debility. It is not a little remarkable, that a disease of such extreme violence should, until comparatively of late years, have passed without observation, or at least have not been noticed as a specific affection; and even now, those writers who have treated of it have entertained the most opposite ideas of its nature and management. Some authors have described it as a fever of the most acute inflammatory kind, some as of the typhous type, and others as possessing a specific nature, not agreeing in its characters with any other febrile affection. This diversity of opinion with respect to its inflammatory nature has probably arisen from the stage to which it was advanced when it fell under observation; but we are disposed to consider the last opinion as, to a certain degree, correct, for the disease never occurs except in the puerperal state, and there is reason to believe that it is capable of being propagated by contagion from one individual to another. So far as dissection throws any light upon the nature of the complaint, it seems to be produced, or at least accompanied, by inflammation of the peritoneum and uterus; but the symptoms are not exactly the same with those attending inflammation of those parts when arising from any other exciting cause

The same uncertainty, or rather the same diversity of opinion has existed respecting the treatment of puerperal fever as respecting its cause; those writers who have conceived it to be essentially an inflammatory affection, have recommended very copious depletion, while the opposite party have enjoined the exhibition of wine and cordials. Between these opposing sentiments it may appear rash to decide peremptorily, as by so doing we must inevitably set ourselves in opposition to the experience of those, who, from their situation and knowledge, might be supposed capable of forming a correct judgment. But, notwithstanding these considerations, we are disposed to decide in favour of the opinion which regards the disease as properly belonging to the class of inflammatory complaints, but at the same time having something specific or peculiar in its nature, depending upon its connexion with the puerperal state, perhaps arising solely from a strong inflammatory action supervening upon a previous tendency to debility, as induced by the process of parturition. But whatever be the intimate nature of the inflammatory diathesis, it appears in fact to be short in its duration, and to be succeeded by a state of extreme exhaustion, from which it is impossible to recruit the powers of the system.

The practice corresponds with this view of the nature of the disease. If it be seen in a sufficiently early stage, we must have recourse to the most vigorous antiphlogistic means, especially very copious bleeding and purging; but if this stage be passed by, those remedies are no longer admissible, and although the chance of recovery must now be considered as extremely little, probably the best course will be to employ small doses of excitants and stimulants. It is not easy to conceive by what train of causes such a disease should prevail epidemically, yet this seems to be certainly the case. No adequate exciting cause has been hitherto assigned for it; it does not appear to be induced by any peculiarity of constitution, nor by any thing uncommon or unusually severe in the process of parturition. We have remarked above, that the disease is thought to be contagious, and there is reason to suspect, that the person of the attendant is the channel through which the contagion has been conveyed. The necessary means of precaution must, therefore, be strictly adhered to; and it may sometimes be even desirable for the practitioner to suspend altogether, for a certain length of time, the exercise of his profession.*

SECT. VIII. *Inflammation of some of the smaller Organs.*

There still remain to be considered some species of Phlegmasiæ, which strictly belong to the same genus with those that we have just been examining, and, indeed, differ from them only in their more local nature, depending upon the small size of the part affected. The most important of these, from the functions which they exercise, and the frequency of their occurrence, are the inflammation of the eye, the ear, the mamma, and the testis.

The inflammation of the eye, or ophthalmia, is sufficiently obvious by the external appearance of the organ, by the pain and heat, and by the intolerance of light. Different parts are, at different times, more peculiarly the seat of the complaint: this most frequently is the conjunctiva, the external membrane covering the ball. Sometimes the inflammation seems more immediately to attack the substance of the ball itself, and at other times the lids are principally affected; but it generally happens, that when one part has been the primary seat of acute inflammation, it is extended, in a greater or less degree, to all the rest. The exciting causes are various. Most frequently it may be traced to exposure to cold, or to some mechanical body acting immediately upon the organ; but, at other times, it seems to be more immediately connected with a peculiar state of the constitution; and there is strong reason for believing, that one of the most severe forms of the disease originates from a specific contagion. Although the inflammatory action in this disease exists in its most acute state, yet, from the small size of the part affected, it seldom excites any degree of general fever. With respect to the contagious form of the disease, to which we alluded above, its existence seems now well established. We have long been in possession of accounts from various travellers in Egypt, of the extreme violence of the disease in that country. These reports were but too amply confirmed by the English army during the Egyptian campaign; and we have also had equally abundant evidence of the fact, that the disease retains its violence when transmitted to this country, and generates a matter which is capable of exciting it in a sound eye to which it is applied. Whether the Egyptian ophthalmia be essentially a different complaint from the more ordinary forms of the disease which occur in this country may be doubted; but it actually differs from them in its much greater violence, in its contagious property, as well as in the part more immediately affected, which appears to be the substance of the globe itself, and likewise in the nature of the matter discharged, being rather purulent than merely mucous. It is generally supposed, that a proper ophthalmia, although marked by some specific characters, may originate from certain morbid states of the constitution, especially from syphilis and scrofula. Ophthalmia, like most other inflammations of the membranous organs, when it has once existed in a severe degree, is liable to be reproduced by slight causes; and this is particularly the case with respect to external cold. The different states of acute and chronic are perhaps more distinctly marked in this than in any other of the Phlegmasiæ. The difference appears to depend partly upon the exciting cause; partly upon the state of the constitution; and in some degree upon the texture primarily affected. When the membranes covering the globe, and, still more, when the globe itself is affected, the disease is in its most acute form, while the inflammation of the tarsi, or the contiguous parts, is of a less active character. This latter variety occurs the most frequently as a constitutional affection, either connected with a scrofulous habit of body, or simply as an indication of general debility.

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* On this subject the text seems somewhat unsatisfactory. Puerperal fever ought to be divided into the idiopathic and symptomatic kinds; in the former we may observe the characteristics of an active but pure inflammatory disorder; while in the latter are to be seen those of a typhoid affection. This typhoid state is to be considered as depending upon a peculiar condition of the system and previous exposure to the sources of typhus fever. In this case puerperal fever is not unfrequently highly contagious.—These two forms of the disease evidently call for different and opposite modes of treatment.

HOSACK.

The treatment of ophthalmia is, in a great measure, local; and, in its earlier stages, and more acute state, consists in the detraction of blood from the vessels in the neighbourhood of the part affected, and the subsequent application of blisters. We are, at the same time, to employ purgatives, and the other parts of the antiphlogistic plan. We are to permit the organ to remain at perfect rest, and especially to guard it from the action of light. When, from the character of the epidemic, or from the nature of the symptoms, we suspect the disease to consist of the Egyptian variety, or to have attacked the internal part of the organ, we are to use more active treatment, and especially very copious general bleeding. It may be questioned, whether, under any of these forms, much advantage is obtained from the use of collyria; or, if we are to expect any benefit from them, it must be by removing the acrid discharge from the eye, which is best accomplished by pure water, or perhaps a mixture of milk and water, at the temperature which is the most agreeable to the sensations. In the chronic stage, or when the violence of the first inflammation has been reduced, astringent or stimulant washes, or ointments, are generally had recourse to, yet the number of them which have been, at different times, strongly recommended by their respective advocates, and the various ingredients of which they are composed, render it extremely difficult to decide upon the degree of benefit which has been derived from them, or upon what the beneficial effect depends. When mere astringency is thought to be indicated, probably the best remedy is the sulphate of zinc; if we wish to have a union of an astringent with a sedative, we may conceive the acetate of lead more proper; and when our object is to stimulate the parts, more especially the glands of the tarsi, we may use ointments, of which the oxides of mercury or copper are the chief ingredients. In the same class of stimulants, we shall be disposed to place the diluted tincture of opium, where we conceive that the primary action of the substance on the eye must have much more power in exciting the part, than any general sedative effect which can subsequently arise from the action of the opium. When the disease is a symptom of any constitutional affection, it is obviously necessary to remove this affection before we can cure the local disease of the eye. As the Egyptian or purulent ophthalmia is propagated by the application of the matter discharged from the part, it is peculiarly necessary to use every precaution to prevent this communication; and especially in schools, or other large collections of persons who live under the same roof, we should be careful to separate those who are affected from their fellow-inmates.

There is a peculiar variety of the complaint, which indeed strongly resembles the Egyptian, that is confined to newly-born children: it consists in a very violent inflammation of the whole substance of the eye, and generates a matter which seems to be decidedly purulent. It has been supposed to be produced by certain morbid discharges from the mother, coming into contact with the eyes of the infant during its birth; it may probably be always prevented by a due attention to cleanliness, which is the more important, as from the violence of its symptoms, and the tender age of the subject, its effects are generally very distressing.

We have little to remark concerning the inflammation of the ear, which, although occasionally extremely painful, and so severe as to terminate in the destruction of the internal parts of the organ, is usually of a transient nature, and not often the subject of direct medical treatment. The inflammation is generally so limited in its extent, and is seated so far out of our reach, that bleeding is seldom employed, nor is the constitution so much affected as to render any general remedies necessary. By excluding the cold air, by dropping warm fluids into the ear, and by blisters, the complaint is commonly relieved; opium, both internally and externally, may be employed, especially in the latter stages. The inflammation of the mammæ and the testis are painful affections, but, as they are altogether local, and are removed by the usual remedies for local inflammation, we shall not enter into any particular account of them in this place.

We have now gone through the important genus of the Phlegmasiæ, and we may remark concerning them, that they afford us the most evident examples of the efficacy of the medical art, and equally prove the fallacy of the pathological doctrine which conceives diseases to be merely efforts of nature, directed to the removal of some noxious or offending cause from the system, and that the object of our remedies should be solely to promote these natural efforts. The direct tendency of the phlegmasiæ is to destroy the functions of the part affected, while the operation of the depleting plan of treatment is directly to oppose the disease, and to induce a state of the system precisely the reverse of the morbid one. There is no class of diseases in which a prompt and decisive judgment is so requisite, or where any temporizing or hesitation in the mind of the practitioner is productive of more dangerous consequences. As these diseases are scarcely in any degree under the influence of the imagination or the control of volition, we are, on that account, better able to judge of the operation of remedies, and consequently can with more certainty apply the experience that we have acquired, and predict the effect of our treatment, than in other cases.

Sect. IX. *Defluxiones. Catarrhus; Bronchitis.*

Our next genus is that of the Defluxiones, which consist in an increased secretion from a mucous membrane attended with fever. The only diseases which seem naturally to belong to this genus are, Catarrhus, Bronchitis, and Dysenteria; for, although some of the affections of the larynx, the trachea, and the urinary organs, would come under this definition, yet, in their general symptoms and tendency, they approximate so much more to the Phlegmasiæ, that we have preferred placing them in that genus. We are not thoroughly acquainted with the cause of this difference, why the inflammatory action, both general and local, is so much more acute in one case than in the other, or what constitutes the essential difference between Enteritis and Dysenteria.

It will be unnecessary for us to enter into any long detail of the symptoms of the well known affection catarrh, the great endemic of our island, and the fruitful source of so much real and so much imaginary evil. Its usual exciting cause is sufficiently designated by its popular designation of cold; for notwithstanding some speculations of an opposite nature, which ascribe catarrh to the action of heat of the body, after a previous exposure to cold, we still adhere to the commonly received doctrine. The contrary opinion, we have no doubt, arose from imperfect observation and false analogy, and is contradicted by daily experience, where we observe innumerable instances of individuals being attacked with the symptoms of catarrh during the actual application of the cold, provided it be sufficiently long continued. We believe, however, that a sudden transition from a very cold to a very warm atmosphere will aggravate the injurious effects of the former; and there are likewise some cases, where, from an indirect or secondary effect, cold air, or even the cold bath, has removed a catarrhal affection. We have, however, no hesitation in recommending, as the general remedies, a moderately warm temperature, the plentiful use of weak tepid drinks, the warm foot bath, low diet, gentle aperients, and what may be styled the mild antiphlogistic regimen. But the prevention of catarrh is a more important object than its cure, which is, for the most part, easily effected, while the extreme susceptibility of some individuals to the least degree of coldness and moisture renders them subject to perpetual anxiety, and unfits them both for the enjoyments and the duties of life. The great point consists in avoiding all violent extremes of temperature; for we have abundant evidence, that the comparative are much more felt than the positive degrees of cold, and next to this, in increasing the capacity which the system possesses of what is styled re-action. The first object is principally accomplished by warm cloathing and cool rooms, and the second by temperance in diet, by bodily exercise, and by the regulated use of the cold bath. Besides external cold, which we regard as the most frequent cause of catarrh, the disease sometimes prevails epidemically, and seems to be propagated by contagion; in this case, the symptoms are generally more severe, and its attacks are more sudden, but it does not differ, except in degree, from the ordinary form of the disease.

Bronchitis has generally been considered, not as a distinct affection, but as a species either of catarrh, or of pneumonia; it seems, however, to be distinguished from the first of these by its seat, and from the latter by its symptoms, as it consists of an affection of the bronchiæ very analogous to that of the mucous membrane of the nose and fauces in catarrh. But although we may consider bronchitis to be a distinct disease, its nature is obviously very similar to that of catarrh: the two affections are frequently connected together; the former is often the effect or sequel of the latter; and they run into each other by insensible shades or gradations. The principal difference depends upon the more chronic nature of bronchitis, and its being connected with particular constitutions and ages, rather than originating from the mere action of an external exciting cause. When the bronchiæ are the seat of the disease, in addition to the remedies for catarrh, we shall derive benefit from blisters; and we may also advantageously administer expectorants, especially squills and small doses of ipecacuanha; when it assumes the completely chronic state, opiates may be properly added to the other remedies. It is a disease, however, which is frequently so protracted, and which has its symptoms so much modified by external circumstances, and by the condition and habits of the individual, that it is difficult to lay down any plan of treatment that will be applicable to all the cases that come under our care.

Sect. X. *Dysentery.*

Dysentery is a disease which appears essentially to consist in a state of the alimentary canal analogous to that of the fauces in catarrh. It is characterized by severe griping pains, tenesmus, and frequent small evacuations, which consist chiefly of mucus, occasionally tinged with blood: the fæces are altogether retained, or are discharged in the form of rounded masses, called scybala. The exciting cause of dysentery seems to be very similar to that of intermittent fever; it generally prevails in the same situations and seasons; but although many speculations have been formed concerning its nature, and the way in which it is generated by autumnal fogs and marsh effluvia, they do not appear to us in any respect satisfactory. The disease has been supposed to be sometimes produced by certain peculiarities in diet, but of this we apprehend there is not sufficient evidence; and with respect to the use of recent fruits, we conceive that they would rather tend to prevent the disease. It has been generally supposed that dysentery is contagious, but we confess that we are inclined to adopt the contrary opinion, as the mode of its propagation more resembles that of a complaint attacking a number of individuals, all exposed to the same exciting cause. Dysentery is often combined with typhus, and it is said that when the fever is communicated by infection, the dysenteric symptoms are so likewise. Generally the most violent forms of the disease occur in warm climates, and in situations where the body is exposed to extreme alternations of heat and cold, so as to have given rise to the idea, that it has some connexion with the state of the cutaneous perspiration. Many circumstances, both with respect to the cause and the treatment of the disease, favour the reality of this connexion, although it is not easy to give any intelligible account of the mode of its operation, for the hypotheses that have been formed on this subject are little more than mere expressions of the fact in technical language, or have consisted in assuming the very point which was to be proved.

The ultimate object to be aimed at in the cure of dysentery is to restore the healthy action of the intestines, while the immediate object is to procure a discharge of the fæcal matter. A great variety of remedies have been employed for this purpose, but, for the most part, they may be all reduced to two classes, purgatives and diaphoretics. The purgatives that have been found the most effectual, are of the milder description, and are to be administered in small, but frequently repeated doses; oleum ricini, neutral salts, and senna, to which we may add small doses of calomel, are perhaps among the most useful; and, either combined or alternating with ipecacuanha and antimony, undoubtedly have a powerful effect in restoring the due action of the bowels. Injections are useful in promoting the operation of the purgatives; fomentations to the abdomen sometimes give relief to the pain, and where it is very severe and fixed to one spot, leeches and blisters may be applied; while there are other auxilliary means that may be used to meet particular symptoms. It does not appear that general bleeding is frequently necessary, but wherever any considerable degree of fever is present, it should be had recourse to without hesitation. Until the fæcal discharge has been fully established, opium is inadmissible, but after this has been accomplished, it may be given with great relief to the pain and tenesmus, especially in the form of Dover's powder. When the disease exists in a very violent degree, and has not been properly attended to in its earlier stages, more acute inflammation appears to supervene on portions of the intestines; there is sometimes an exudation of lymph from the internal surface, and after death we find their structure so entirely disorganized, that scirrhous ulcerations and even gangrene have been induced.

The above remarks on the treatment of dysentery chiefly apply to the disease as it exists in our own country, or in the temperate climates of Europe; in the equatorial regions, where the disease assumes a much more malignant and formidable appearance, we have strong evidence in favour of the efficacy of large doses of mercury, both given internally and rubbed on the surface, so as to produce salivation. Whether the complaint for which this treatment has been employed is to be regarded as proper dysentery, or, if it be so, how far it may be modified by climate, we do not presume to decide; but we unquestionably think that such a plan of treatment is not necessary, or even admissible, for the disease, as it comes under our observation. When it has existed in a violent form, after its urgent symptoms have been subdued, it is not unusual for an irregular action of the bowels to continue, which terminates in an obstinate diarrhœa. In this stage astringents have been generally employed, and a great variety of them are recommended, which have generally been given in combination with opium. We think it doubtful whether these remedies can answer the end for which they are prescribed; if they are ever found beneficial, we conceive it more likely to be from some tonic power which they exercise upon the stomach, thus improving the general state of the health and the digestion, than from an astringent operation on the intestines themselves: we may farther remark, that when the disease acquires this chronic and protracted form, it is always difficult to discriminate between the effect of remedies and the natural powers of the constitution. Upon the whole, we think the best plan of treatment in such cases is to aim at restoring the digestive organs to their healthy state, to employ the least stimulating kind of diet, to allay irritation by opium, to regulate the external temperature, and occasionally to administer mild purgatives.*

SECT. XI. *Rheumatism.*

Our next genus of the Phlogismi is Rheumatism, a disease which appears to consist in an inflammation of the tendons, or other membranous parts connected with the muscles, principally those which serve for the motion of the larger joints. It is characterized by heat, pain, and swelling, of the part, with difficulty of motion, attended by an acute degree of cauma. Its cause is probably in all cases the application of cold and moisture, and especially when acting locally upon particular parts only of the body; but, like many other of the inflammatory affections, when the disease has been once experienced in any considerable degree, it affects the constitution so as to render it afterwards capable of being reproduced by very slight causes. There is no disease which presents such remarkable examples of metastasis; it is not unusual for a part that is suffering from a violent attack of the complaint suddenly to lose every morbid symptom, while it is immediately transferred to some other part, quite remote from the former, as from one knee to the other. We are unable to explain the mode by which this is accomplished; but of the connexion of the two occurrences, the disappearance of the disease in the first, and its accession in the second part, there can be no doubt. While the humoral pathology was in vogue, these phenomena were easily explained upon the principles of this hypothesis, and they were adduced as some of the strongest arguments in favour of the existence of a morbid state of the fluids, which, being from any cause repelled from one part, made its appearance in some other organ.

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* The author has not adverted to the connection that subsists between this disease and the state of the liver, which very frequently is affected by a diminished secretion of bile, and thus induces a consequent derangement of the digestive organs. Among the most effectual means of restoring the functions of the liver, and a copious discharge of bile into the intestines, and thereby of counteracting the septic state of the contents of the bowels, is the use of emetics. These in the first stage of dysentery disarm the disorder of much of its violence and febrile irritation. In like manner, after the use of cathartics as recommended above, much advantage is to be obtained from small and repeated doses of ipecacuanha. The mercurial treatment has many advocates; but my experience does not sanction the use of this metal in dysentery, as the complaint appears in this country. Mercury not only adds to the inflammatory symptoms, but greatly aggravates the tenesmus, and increases the morbid discharges, so characteristic, from the bowels. The influence of diet in the production of this disease has long been established, upon the testimony of Pringle, Monro, Blane, and others. The want of fresh vegetables, an excessive use of animal food, especially of salted provisions, I have observed to be a frequent cause of this disorder in the New York State Prison.

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Rheumatism is a disease in which the two states of acute and chronic are particularly well marked; the chronic is generally the consequence or the sequel of the acute, but there are many instances in which a less degree of the existing cause produces the chronic variety, yet, as it is difficult to distinguish a slight degree of acute rheumatism from the chronic kind, we frequently cannot decide to which variety these more local affections should be referred. The chronic Rheumatism differs from the acute in the absence of general fever; in the inflammation of the parts possessing less urgent symptoms, being characterized almost entirely by pain and stiffness; by the tumour, if any, being permanent; and by the complaint being much less liable to metastasis. There is a farther diagnostic circumstance, that while the acute Rheumatism is generally aggravated by external warmth, the chronic, on the contrary, is certainly relieved by it. Chronic Rheumatism is one of those affections that have the property of indicating, in a way which we are not able to explain, the future changes of the weather, so that patients of this description can predict these changes before any signs of them have been manifested by our usual meteorological instruments. Many animals possess this power in their healthy state; in these cases it is generally referred to the operation of instinct, as it is always found to be connected with some circumstance essentially necessary to their immediate existence or their future welfare.

The seat of Rheumatism is supposed not to be in the muscular fibre itself, but in the membranous parts connected with it, an opinion which is derived partly from the sensation of pain being referred, not to the belly of the muscle, but to the joints, and to the joints being the principal seat of the external inflammation; the changes of structure which occasionally occur after some attacks of the disease, are always found among these parts, consisting of the thickening of the tendons, the adhesion of the membranous parts to each other, or the deposition of a fluid into the interstices. Rheumatism is a disease which seldom proves fatal, but it is one which, from the pain that it occasions, from its liability to relapses, as well as from the injury which it often produces in the organs of loco-motion, is to be regarded as a very serious complaint; and it is more to be dreaded, because, notwithstanding the frequency of its occurrence, and the numerous cases which must come under the notice of every practitioner, we are still very much in doubt respecting the best method of treating it. We find indeed various works, which lay down certain plans of treatment with the greatest confidence, and the fullest assurance of success, but, at the same time, we find authors recommending plans of exactly a contrary tendency, one of which must necessarily be improper, unless we imagine that they are both of them equally useless.

With respect to the treatment of acute Rheumatism, it naturally resolves itself into two leading indications; first, to remove the general state of fever; and, secondly, to relieve the local affection, although it may be remarked in this, as in all the other Phlegmasiæ, that these indications are, to a certain degree, necessarily connected together. Almost all systematic writers have directed us to commence with blood-letting, which in this, as in other inflammatory febrile affections, is to be repeated, until the increased action of the sanguiferous vessels be reduced to its proper standard. We are then to administer purgatives, to employ the antiphlogistic regimen, and excite the cutaneous perspiration by diaphoretics and sudorifics. In the first stage, little is to be done with respect to the local complaint, but where the febrile symptoms have been subdued, we may advantageously apply blisters, or stimulating liniments, fomentations, and friction. The disease has been supposed to possess a peculiar tendency to induce a state of general debility, and this state must of course be aggravated when the depleting system has been carried to any considerable extent; it is therefore generally deemed necessary, in the later stages, to employ tonics of various kinds, and more particularly cinchona.

The above constitutes what may be regarded as the ordinary method of treatment, and which appears to accord the best with our opinion of its nature and proximate cause, yet we have the testimony of men of the first eminence in favour of a very different system of management. By some of these, bleeding is entirely discarded in Rheumatism, as of no use in diminishing the febrile action, and tending to bring on the subsequent state of debility, which is very difficult to remove, and permanently injurious in its effects. Sudorifics are likewise thought to be useless in their immediate, and detrimental in their ultimate operation; while the cure of the complaint is, from the first, trusted to cinchona and other tonics, with occasional opiates to relieve the pain, and such topical applications as may, from time to time, seem to ease the pain and relieve any urgent symptoms. Some practitioners have placed confidence in the effects of mercury as a remedy for Rheumatism, and others have depended upon opium, not merely as a palliative, but from some supposed operation on the system at large. Our own experience in the disease, although considerable, has not, we confess, enabled us to decide with certainty upon all these points; or, perhaps, we may say more correctly, has rather led us to conclude, that certain plans of treatment are useless or injurious, than to determine what methods ought to be substituted for them. We should not altogether proscribe bleeding, but we believe that it is not a remedy of extensive application; sweating we are disposed to regard as positively bad, at least if carried to any considerable extent: nor do we feel much disposed to place that confidence in cinchona which the respectability of the names attached to this practice would seem to warrant. Upon the whole, the plan of treating acute Rheumatism which we should recommend, is to bleed occasionally and moderately, to administer purgatives very freely, to abstain from all the direct means of producing direct perspiration; but not, however, to check any natural efforts of this kind by external cold, and to exhibit opium in moderate doses, combined either with ipecacuanha or with calomel.

The cure of chronic Rheumatism, although by no means easy to be accomplished, is, however, a subject of less controversy. Here we have no febrile action to subdue, and our indications are to relieve the topical affection, and to restore the strength of the system. If the parts be tender, as well as painful, leeches and blisters may be applied, but, for the most part, fomentations and stimulating liniments seem to be more useful; in the application of which latter remedies there is no doubt that a large share of the benefit is derived from the quantity of friction which is employed. Much real advantage appears to be obtained from the efforts of the patient to move the affected part; and when he can be prevailed upon to make the necessary exertions, in spite of the pain and difficulty attending the first trials, the effects that have been produced are truly astonishing, and have probably, in former times, often given rise to the belief in supernatural agency. Calomel and opium will be found useful, if the pain be considerable, and a gentle diaphoresis may be procured by Dover's powder, or the combination of guaiacum and ammonia. Considerable relief is sometimes obtained by the application of bandages to the affected joints, by which they are rendered more capable of motion, at the same time that the absorption of the effused fluid seems to be promoted, or perhaps the effusion altogether prevented. In the later stages, when stiffness is the chief remaining cause of uneasiness, the warm bath is of great service, and particularly in the form of the natural thermal springs of Bath or Buxton, where, however, the only advantage over the common warm bath consists in the large quantity of water, so as to enable the patient to move about while immersed in the fluid. Baths of warm sea water have been thought particularly useful, and, if they could be procured sufficiently capacious, might perhaps be superior to natural springs, in consequence of the saline particles stimulating the cutaneous vessels, and tending to excite their action. Very high commendations have been bestowed upon the vapour bath, and, in some obstinate cases of chronic Rheumatism, arsenic has been said to be beneficial. Electricity, oil of turpentine, and various acrid vegetables, are among the remedies which have been employed at various times: and, where other means have failed, a course of mercury, given so as to induce salivation, is reported to have been successful. To prevent the recurrence of the disease, woollen should be worn next to the skin, and the other means adopted which we have mentioned above as useful in the prevention of Catarrh; to which we may add, that, in Rheumatism, exercise is of the most essential importance, and must indeed be persevered in to an extent which, in ordinary cases, would be regarded as excessive.

Sect. XII. *Inflammation of the Cellular Texture and of the Skin.*

The inflammation of the cellular texture, giving rise to boils of various descriptions, and the simple inflammatory affections of the skin, producing different kinds of papulous eruptions, we have placed in this part of our system, under the names of Phlogosis and Erythema. They are generally local affections, and for the most part are scarcely of sufficient importance to require medical treatment, but occasionally they become the objects of attention, both from the pain which they produce, and still more from their affording an indication of a morbid condition of the system, which it becomes an object with us to counteract. Although they frequently arise from obvious accidental causes, it is no less certain that they sometimes proceed from a peculiar state of the constitution, an observation which coincided so well with the doctrines of the humoral pathology, as very probably to have led to the exaggeration of the facts on which it was founded. When the functions of circulation or secretion are either of them suffering from irregular action, it is easy to imagine the partial derangement in the transmission of the fluids through the capillary vessels may ensue, without having recourse to the idea that the fluids themselves are in an unfavourable state; and if we find the tendency to the formation of these local inflammations to be removed by purgatives, or by a more strict attention to diet, the effect is readily explained by the improvement which hence takes place in the different functions that are connected with the process of digestion, without conceiving that the former have expelled any morbific humours, or that the latter has any effect in sweetening the blood. Large abscesses frequently occur as the sequels of severe fevers; and it is often supposed that persons who have long laboured under a delicate state of health have been relieved by the appearance of these affections. After the shock which is given to the circulation in fever, we cannot be surprised at the occurrence of any local derangements of this kind; and, with respect to the latter case, it is not improbable that some change from a feeble to a more active state of the circulation may produce these partial congestions, being not the cause, but the concomitants of convalescence. We shall not offer any observations upon the treatment of these complaints, as it is generally supposed to belong entirely to the province of surgery; but with respect to the state of the constitution in which they are the most apt to make their appearance, we may remark, that it is relieved by a long continued use of moderate purgatives, of which it is generally supposed that calomel ought to form a part; by strict attention to diet; by exercise; and, according to the state of the appetite, either by stomachics or by tonics. Courses of mineral waters are often serviceable, but, for obvious reasons, it is necessary that they should be drunk at the fountain head.

Sect. XIII. *Hectic.*

As a kind of appendage to our order of Phlogismi, we have placed Hectica, a disease which consists in a peculiar febrile action, which generally appears to be sympathetic of some other affection, but which necessarily becomes itself the immediate object of our attention. Hectic is indicated by a frequent, but feeble pulse; by circumscribed flushes of the cheeks; by heat in the palms of the hands, and soles of the feet; by profuse perspirations; by watery alvine evacuations; and by a deposition from the urine of what has been termed the lateritious sediment. The fever is remarkable from its periods of accession and decline; it comes on at a certain stated hour, which is generally in the afternoon or evening, the patient goes through the successive stages of chilliness, heat, and perspiration, and is, after some hours, left comparatively free from complaint. Most systematic writers inform us, that it is not unusual in hectic for there to be two paroxysms during each diurnal revolution; but of these we have some doubt. The appetite remains, for a considerable time, without being much impaired, and although the prostration of strength is very great, and the patient is daily harrassed by a variety of distressing symptoms, yet it is a striking feature of the disease, that the spirits are little affected, and that he retains his hopes of recovery almost until the last hour of his existence. There is no disease in which the body suffers so remarkably from the effect of mere emaciation; it appears as if every part suffered in exactly the same proportion, so that life is enabled to continue, although the actions of the machine are reduced to their lowest possible pitch, until they all cease together.

Hectic is obviously, in a great majority of cases, sympathetic, and depends upon the presence of some local affection, generally of the nature of an abscess, thus giving rise to an opinion, that it was immediately caused by the absorption of pus. Of this absorption, however, there is no evidence, and it rather appears that hectic is the consequence of a change in the system induced by the process of suppuration, or even of the previous inflammatory action that gives rise to this process. Although, in most cases, we are able without difficulty to assign the cause of the primary complaint, yet this is not always the case, and there are a few instances in which it would appear, that a mere mental affection has produced a febrile state, very nearly, if not altogether, identical with the usual form of hectic. Of this we have a noted example in the Nostalgia of the systematic writers, an actual disease, which is brought on by the anxious desire that is sometimes experienced by individuals to return to their native country, after a long absence from it. We may presume, that it is a high degree of this feeling, aggravated no doubt by a variety of circumstances unfavourable to the bodily health, that constitutes Cachexia Africana.

The cure of hectic may be comprised almost in the single indication of removing the exciting cause; where this can be accomplished, the fever soon disappears, and all the functions resume their natural action, while without it, we doubt whether there be a single remedy which can be of any essential service. It indeed often becomes an important object to endeavour to remove the particular symptoms, as their immediate effect is sometimes so injurious to the system, as even to increase the original disease. The symptoms which we are the most frequently called upon to remove, are the sweating and the diarrhœa; but it too often happens that all our efforts for this purpose are unavailing. Besides, we unfortunately find, that whatever checks one of these discharges tends to increase the other; thus, if we use acids, or admit cool air to the surface of the body, to diminish the perspiration, we aggravate the diarrhœa, while by warmth, opium, and astringents, we perhaps remove the diarrhœa, but bring back the perspiration. The tendency which the body has to fall into a state of profuse sweating during sleep is remarkable, and what we are not well able to account for; but we observe the fact, and find our efforts to prevent it quite ineffectual. Of these two affections, the perspiration, however profuse, is to be regarded as less injurious than the colliquative diarrhœa, and therefore we are, at all events, to endeavour to obviate the latter, although we may, by this means, necessarily bring on some degree of the former. For this purpose, we must employ astringents, such as catechu, kino, and hæmatoxylon, combined with chalk and opium; and if there be much increase of temperature, with thirst and dryness of the fauces, diaphoretics will be found necessary, notwithstanding their action on the cutaneous vessels might seem an objection to their use. The diet should be nutritive, but as little stimulating as possible; and it is of great consequence that the patient should be preserved in a uniform temperature, in order to avoid that excitement of the sanguiferous system which is caused by reaction. Digitalis has been recommended as a remedy for hectic, as well as belladonna, conium, and some other vegetable narcotics; and we have had the most confident accounts of the beneficial effects of carbonic acid in allaying the irritation, and especially in retarding the pulse by its sedative operation; but these flattering prospects of success have never been realized, when the remedies have been tried by any other persons except those who originally proposed them, or their professed advocates. Upon the whole, the treatment of hectic is to be regarded as entirely palliative, and chiefly negative; we may be of some use in removing causes of irritation, and in preserving the system in a tranquil condition, until the disease can be effectually removed by the removal of its exciting cause.

SECT. XIV. *Pyrexiæ. Idiopathic Fevers.*

The second order of the Parhæmasiæ we have denominated Pyrexiæ, by which we mean diseases originating in a disturbance of the sanguiferous system, producing the febrile state, but where the nervous functions are likewise necessarily affected. This constitutes the class of diseases which are commonly called Fevers, when we use the term in its more restricted appellation, as intended to include those only which are idiopathic, and are not connected with local inflammation. The Pyrexiæ form an order of diseases, which, with respect to their frequency and their violence, taken conjointly, have proved the most destructive to the human species; some of them are capable of generating the most virulent contagion, others owe their origin to causes that prevail the most extensively, and are, at the same time, the most beyond our power individually to control, as peculiar conditions of the atmosphere with respect to moisture and temperature, or of the country which we inhabit, as to its soil, its productions, and its state of agricultural improvement; while a third set of causes is derived from circumstances, which, although induced upon mankind by their own voluntary acts, to the great bulk of them are no less inevitable than the evils which are immediately inflicted by Providence itself, and are frequently more dreadful in their effects.

The number of works that have been published on the subject of Fever, both pathological and practical, is in proportion to the magnitude and importance of the subject. Each successive revolution in medicine has produced a new hypothesis of Fever, for this has generally been the object to which the theorist has first directed his attention; while, from the various aspects which Fever assumes under different circumstances, every country and every age have given rise to some new opinion respecting its origin, its nature, and its tendency, and has produced some new plan for its treatment. It would be in vain to attempt even an outline of all these different doctrines, and opinions, and controversies, within the compass of a few paragraphs; referring therefore merely in a casual manner to what has been done by others, we shall set forth, as briefly as possible, our own ideas upon the subject.

And, first, with respect to the arrangement of idiopathic Fevers; there is one circumstance which obviously divides them into two genera; the first of which consists of what may be styled simple Fever; the second, in addition to the usual symptoms, is attended with a cutaneous eruption, subject to a regular course with respect to the period of its progress, and which constitutes an essential part of the disease; to the former, we apply the general term of Febres; the latter have been usually styled Exanthemata. Simple fever has been divided into different classes, sometimes depending upon its symptoms, and sometimes upon its supposed causes: perhaps we shall find it the most useful plan to employ in our arrangement a combination of the two circumstances. With respect to the symptoms, there is one point of very obvious distinction between the different forms of the disease, which has always been adopted as the basis of every arrangement, whether the Fever consists of distinct paroxysms, or of an unbroken series of morbid actions, without any regular or periodical interruptions. By a reference to this point, we have the division of Fevers into intermittent and continued. A farther division of the same kind has been attempted, upon the principle that the Fevers which have no proper or complete intermissions, have still what were called remissions, in which, at a certain period, the symptoms assumed a less aggravated form, although without their being completely removed. These remissions are no doubt to be observed in many forms of the disease, especially in the Fevers of warm climates; but it is so difficult to draw a clear line of distinction between those which exhibit these remissions, and those which are entirely continuous, that we think it is not possible to admit the circumstance to form the characters of the primary divisions.

With respect to the causes of Fever, we have first to inquire whether it be propagated by contagion or not; and when this can be clearly ascertained, it may be considered as a sufficient ground of distinction. Intermittent Fevers are known not to be contagious; but with respect to continued Fevers, it seems probable that some are propagated by contagion, and that others are not so. Of the former description is Typhus, and of the latter description appears to be the Fever of America and the West Indies, for this we consider to be the result of the long an virulent controversy that has existed upon this question. Hence, we obtain a division of continued Fevers into the Typhus, or contagious Fever of the temperate zone, and the pestilential non-contagious Fever of the tropical climates. These will form our three genera of Pyrexiæ; and although this classification may appear extremely scanty and imperfect, yet it is all that we consider as at present sufficiently established, and it possesses the advantage of being of that comprehensive nature, which may receive any additions or subdivisions, whenever our increased experience will enable us to proceed to a greater degree of minuteness.

Sect. XV. *Intermittens. Intermittent fever or Ague.*

This species of Fever is designated by its obvious character of being divided into distinct paroxysms, between which there is complete apyrexia, or a total cessation of the febrile action, and an almost perfect restoration of the functions to their healthy state. After a certain number of hours, the first, or cold stage comes on; it commences with a sensation of general weakness and langour; a disinclination to bodily motion or to mental exertion; the face becomes pale; the surface generally shrinks, and feels cold to the touch; while the patient has a sensation of coldness through all his limbs, which produces a shivering or even trembling of the whole body. After some time these symptoms gradually disappear, and are succeeded by those which constitute the hot stage, which is characterized by all the symptoms of reaction. The paleness of the face, and the coldness and shrunk state of the skin, are succeeded by redness and flushing of the cutaneous vessels, and at length by a glow over the whole surface, and this train of symptoms is, after a certain period, succeeded by a copious perspiration, which constitutes the third or sweating stage. The state of all the functions bears a regular ratio to these successive changes; the pulse, the respiration, and the digestive powers, are all languid, and, as it were, inactive during the commencement of the paroxysm, a degree of irregular activity is then excited in them; while, upon the eruption of the cutaneous discharge, they all resume their natural condition. These paroxysms, as has been observed above, succeed each other at regular intervals, but these intervals differ materially from each other, all of them, however, preserving an immediate relation to the diurnal period. The most common form of intermittents is the tertian, where the paroxysm appears only on each alternate day, the intervening one being free from complaint. The next most common species is the quartan, where the apyrexia continues for two days; and then the quotidian, where the paroxysm occurs once in every 24 hours; we have also some unusual varieties, as the double tertian, where there is a paroxysm every day, but where the alternate paroxysms resemble each other more than the intervening ones, to which systematic writers, who have been fond of multiplying cases that bear a marvellous aspect, have added triple tertians, double and triple quartans, and others of a still more complicated and mysterious type.

As there seems to be a necessary connexion between the successive stages, and as they always recur in the same order, or, at least, we never perceive the usual order of things to be inverted, unless under some very peculiar circumstances of obvious disturbance, we thence naturally conclude that the one is the cause of the other; that the condition of the system which constitutes the cold stage is the cause of the hot, and this of the sweating stage, so that, if we are only able to give a satisfactory account of the cause of the first of these stages, we have a clue by which we may explain all the rest.

We have already referred to the great variety of hypotheses which have been formed, to account for the proximate cause of Fever, and we have stated some of the circumstances which appear to us to have led to the erroneous doctrines that have prevailed upon the subject. We shall not, in this place, venture upon the task of forming a new theory of Fever; but we may be allowed to go so far as to observe, that the symptoms of the first stage are those of diminished action, such as might be supposed to arise from the operation of a sedative power influencing the sanguiferous system, and preventing the heart and large vessels from duly propelling their contents towards the capillaries. The increased action which succeeds seems to be the consequence of the previous state of quiescence; but whether this be the case or not, we observe that the one constantly succeeds the other; that the cold is followed by the hot stage; and that in this way the circulation is restored to its healthy state. Without, therefore, saying in what Fever essentially consists, we may assert, that in intermittents there is first a diminished and afterwards an increased action of the heart and arteries, the former giving rise to an accumulation of blood in the internal parts, and the latter propelling the blood with unusual force towards the surface and extremities. It is scarcely necessary to remark, that the effect of this latter change in the balance of the circulation must be, to excite all those actions that depend upon the operation of the capillary vessels, and among others those of the skin; the sweating stage is therefore to be considered as properly nothing more than an effect of the hot stage, the increased secretion of the skin being merely an incidential circumstance connected with the process, by which the circulation is restored to its natural state.

The exciting cause of intermittent fever is now generally supposed to be always the same, the effluvium or miasmata from marshes. It is probable that it operates through the medium of the lungs; but of the mode of its operation we are altogether ignorant; whether the same quantity of sedative action, continued for the same length of time, proceeding from any other cause, is capable of producing an intermittent, is a question that we are unable to answer. The tendency of the disease to recur at intervals which bear a relation to the diurnal period, although in itself a very curious circumstance, is analogous to many others in the animal economy, and may be referred to that class of facts, which shews that at certain times of the daily revolution of the earth about its axis, the body is peculiarly disposed to certain changes or operations. Intermittents have been observed to prevail more in spring and autumn than in summer and winter, a circumstance which obviously depends upon their exciting cause being more active at those periods, in the first case from the increased temperature of the atmosphere beginning to act upon the moistened ground, and, in the second, from the ground becoming moistened after the heat and drought of summer. It gave rise to the division of Intermittents into vernal and autumnal, a distinction to which great importance was attached by the older writers; but it is now simply regarded as a fact, that illustrates the mode in which the marsh effluvium is generated. Although we have stated that this effluvium is the sole exciting cause of the disease, yet it must be acknowleged that many cases occur in which it is not easy to point out its exact origin; and most of the earlier writers have attributed it to a variety of other causes, as simple exposure to cold, want of food, excessive fatigue, &c.; but these and other similar circumstances we regard only as concurring causes, which may render the marsh effluvium more active, but as not in themselves sufficient to produce the disease.

The technical indications of cure in Intermittents, as laid down by systematic writers, are, to cut short the paroxysm, and to prevent its return. If we regard the proximate cause of the disease, or rather that morbid state of the circulation which exists in Intermittents, we may say that our great object is to restore the balance of the circulation, and to prevent any derangement in the viscera which might arise in the commencement of the paroxysm. It is difficult at this time to account satisfactorily for the opinion which existed for many ages, that Intermittents ought not to be cured by the interference of art; for it appears in this case to have been something more than the mere application of the general principle, that the efforts of the vis medicatrix naturæ were in themselves adequate to the removal of the disease. It might perhaps depend, in some measure, upon the real difficulty which practitioners experienced in accomplishing the cure, on which account they shrewdly inculcated a doctrine so well calculated to conceal their ignorance; and perhaps the plan of cure that was then adopted might justify the prejudices that were entertained respecting it; but whatever may have been the case formerly, these fears have now vanished, and we are always happy to cure the disease as expeditiously as our means will permit. The various plans which have been resorted to, and which are stated to have been successful, are very various, indeed so much so, that it is scarcely possible to class them under any general heads, or to reduce them to any common principles. Nor indeed is this much to be wondered at, when we consider, that whatever has the power of exciting the action of the heart may be conceived capable of removing the primary cause of the disease, admitting in this way the application of a long list of remedies, pharmaceutical, mechanical, and mental. Thus, every description of medical stimulant and excitant, upon whatever system or organ they operate, and in short every substance, except those which have a directly sedative effect, have been employed, and, as we are told, with success. External warmth, under all forms, is obviously indicated, and even cold, when applied transiently, so as to induce the subsequent state of reaction, may be used with the same intention; bodily exercise of all kinds, and various modes of mechanically affecting the circulation, as the application of the tourniquet to some of the large arteries. Nor are the remedies which act upon the mental faculties less powerful, consisting partly of substances that are received into the stomach, but which we must suppose act through the medium of the imagination, and partly of such circumstances as are more immediately addressed to this faculty. If the cold stage be passed by, it is doubtful whether much can be done during the paroxysm, except the use of those means that may tend to confirm or promote the natural operation which is established, such as external warmth, mild diaphoretics, and tepid drinks.

But although it is always desirable to attempt to cut short the paroxysm, it is of still greater importance to prevent its recurrence, which properly constitutes the cure of the disease, for it is to be observed, that when a paroxysm has once been experienced, it is liable to return at the usual interval, although the body be no longer exposed to the exciting cause. Our first object is, if possible, to remove the patient from the influence of the exciting cause, afterwards to relieve any morbid effects which may have been produced by the previous paroxysms; and, lastly, to put the system in a condition by which it may be less susceptible of future paroxysms. Whenever any injury has been sustained by previous paroxysms, it appears to be in consequence of a morbid congestion in some organ, to remove which we must have recourse to evacuations; of these purgatives are the most generally applicable, and are indeed almost always indicated; bleeding is likewise frequently necessary, but we must be guided in our use of it by the symptoms of the particular case. The last of the three objects which we pointed out is to be accomplished by evacuations, especially by bleeding and purgatives, where we have reason to fear that any considerable congestion is likely to ensue; and after we have obviated any tendency of this kind, by the assiduous use of tonics during the intervals of the paroxysms. The administration of tonics, and particularly of cinchona, is considered as the great business of the practitioner in the permanent cure of the disease, and is, no doubt, the principal object to which his attention is to be directed; but we apprehend that much of the difficulty which he has met with, and much of the danger which has been supposed to be incurred by the attempts to cure the disease, have arrisen from his not having premised the necessary quantity of evacuations.

Peruvian bark is usually considered as possessing a specific power in the cure of intermittents, but perhaps not very correctly; for although we do not know of of any substance, or combination of substances, which is altogether so proper or so effectual, yet we know of many articles which will in ordinary cases cure the disease; and indeed there are some which have succeeded when the bark has failed. The powers of cinchona seem to depend upon a due admixture of a tonic and a stimulant operation; and practitioners generally add to it some aromatic, which is conceived to render it more efficacious. How far opium is useful in the cure of intermittents is scarcely decided; we are disposed to think that it is not necessary as a general remedy, except in the form of Dover's powder, or in those cases where it is indicated by the state of the bowels or some particular symptoms. Intermittents are peculiarly liable to relapses; and it is a remarkable fact, that when a person has once suffered severely from this complaint, it is for a long time afterwards liable to be brought on by an east wind, although the patient is completely out of the influence of the original exciting cause. When the disease has been violent at its first attack, or has been imperfectly treated, congestions have not unfrequently been produced in the spleen and liver, which have been popularly termed ague-cakes; these are to be removed by a long continued use of mild evacuations, combined with stomachics and tonics; but they not unfrequently lay the foundation for complaints, which resist all our means of cure, and eventually terminate in dropsy. Among the tonics which have been given in intermittents, besides cinchona, we shall only particularise arsenic; this, when taken in properly regulated doses, and with the necessary precautions, appears to possess a still greater power over the disease than even cinchona, and not to be succeeded by any unfavourable effects upon the constitution. Arsenic is however a remedy of so very active a nature, and is so deleterious in its operation, when used in too large a quantity, that we should not wish to employ it unless milder remedies had failed, or were not to be procured; and it may be a proper precaution, whenever it has been administered, to follow its use by a course of purgatives, to prevent its accumulating in any of the alimentary passages.

Sect. XVI. *Typhus. Idiopathic Contagious Fever.*

Our next genus of Febris is Typhus, the idiopathic contagious Fever of temperate climates: from the peculiarity of its symptoms, taken in connexion with the hypothesis that prevailed respecting its nature during the last century, it has been generally named the putrid malignant Fever; and, from the situations where it has been frequently observed to occur, it has acquired the denomination of hospital, jail, or ship Fever. It is recognized by the symptoms of oppression and debility, which manifest themselves in every part of the system from its first invasion. The pulse is quick, weak, and small; there is a great degree of lassitude and feebleness in all the limbs, so as to render motion irksome, or even painful, and the mental powers of all kinds appear to be equally affected. All the animal functions partake of the same kind of debility; the appetite fails, and the stomach is affected with nausea or vomiting; the bowels are torpid, while we have sufficient evidence that the secretions of all kinds are imperfectly elaborated and irregularly discharged. The temperature of the body is variable; at first generally below the natural standard, but it is afterwards elevated a degree or two above it, while the sensations of the patient with respect to heat and cold are irregular and uncertain. The face is at one time pallid, and at another time flushed; the skin is generally parched and dry, or, if perspiration occurs, it is partial only, and has not the effect of restoring the surface to its natural condition. As the disease advances, every thing indicates an increased disturbance of all the vital actions, and an increased irregularity in the mode of their operation. The circulation, the respiration, the digestion, become more and more affected; the temperature is permanently raised above the usual standard; the secretions and excretions assume a more unnatural aspect; and at length even the fluids, while they are still in the vessels, and the solids themselves, lose their ordinary appearance, and are reduced to a morbid state. In the mean time, all the nervous functions are completely deranged; the external senses become depraved; we lose all command over the voluntary muscles; and the mind is overwhelmed with delirium. Without attempting to form what may be called a theory of fever, we may observe in the above train of morbid actions an appearance of three different sets of effects; first, those resulting from the application of a sedative power to the system; secondly, an imperfect attempt at reaction; and, in the last, what may be regarded as the consequence of a derangement of the circulation, and all the functions immediately connected with it.

Notwithstanding the frequency of the disease, the circumstance of its occurring in such various situations, and especially in those countries which have been at all times the best adapted for making observations, yet it may appear not a little remarkable, that almost every question connected with Typhus is yet undecided. With respect to its exciting cause, it is supposed by the majority of writers, that it is produced only by a specific contagion, yet some authors of great eminence have conceived, that other circumstances are capable of generating it; while there are persons who have even denied altogether the existance of Typhus infection. Upon the whole, we are inclined to the opinion, that contagion is always necessary for the production of the disease, but it seems evident, that there are predisposing circumstances likewise necessary, which must operate upon the body, and prepare it for the reception of the proper exciting cause. These predisposing circumstances are all of a debilitating nature, such as want of food and fresh air, exhaustion from fatigue or from previous diseases, grief, anxiety, and other depressing passions, with various analogous circumstances, the primary effect of which is to diminish the vital energy, and thus render the body more obnoxious to the proper exciting cause. An equal uncertainty has existed respecting the nature of the contagion and the mode of its production, whether it be, like the contagion of small-pox, generated only by a person previously infected, or whether it may not be actually produced by impure air, especially when tainted by the miasms of decomposing animal matter, or the exhalations from the living body, when deprived of proper ventilation, although not actually labouring under disease. With respect to these controverted points, there can be no doubt, we apprehend, of the production of a proper contagious matter from the bodies of those previously infected, although it cannot be collected in a material form as in small-pox; we think it probable, that putrid animal matter, however disagreeable it may be to the senses, does not produce any specific disease, while, on the contrary, with respect to the confined exhalations from the body, the balance of evidence seems to favour the opinion, that it possesses the power of producing a proper contagious Fever. A considerable part of this uncertainty has obviously arisen from the invisible and impalpable nature of febrile infection; and, at the same time, from the difficulty which there is in ascertaining what share the predisposing causes have in the ultimate effect, for according to both opinions their intervention is necessary, although they act a different part, and differ in their relative importance.

The mode in which Typhus is propagated, or in which the contagion is conveyed, appears to be two-fold; it is either by being diffused through the air, when it is received into the lungs, or by the contact of the body of the patient, or of the substances which touched his body and imbibed the contagion from it. Of these, the latter is found to be the most certain and the most virulent, and we have many curious facts which seem to prove, that the matter retains its virulence for a long time after it has been thus deposited. On the contrary, the sphere of contagion, as propagated by means of the atmosphere, appears to be very limited, so that, except the body be predisposed to receive it, there is no danger of acquiring the disease from this source, unless we approach within a very short distance of the infected individual.

One of the greatest efforts of the medical art, in modern times, consists in the means that have been devised for preventing or destroying contagion, so that when we are able to command external circumstances, and the patient is willing to submit to our directions, we are able to disarm it of all its terrors, and entirely to subdue that most formidable enemy to human existence. This important object is accomplished by the most simple means, by ventilation and cleanliness; we find, from ample experience, that the limited sphere of atmospherical contagion is rendered still more limited, if not entirely destroyed, by a sufficient change of air, and that a few judicious regulations respecting the ablution of the body, and the careful removal from it of all those substances that are most liable to imbibe contagion, with a frequent renewal of the air, will prevent the concentration of the infection, and thus cut off the great source by which the disease is propagated. The habits of civilized society, especially the crowding together of persons in close cities and manufactories, will probably, in spite of all our best directed efforts, always preserve a large field for the operation of contagion, but it is a most important point that we have gained in becoming acquainted with the correct theory upon the subject, which may enable us to meet the dangers of particular emergencies, although we can scarcely ever expect entirely to eradicate the evil.

A circumstance connected with Typhus, which has given rise to much difference of opinion, respects the existence of what have been termed critical days. It was supposed by the ancients, that there were certain periods of the disease, when it was more disposed to come to a crisis, that is, for some specific change to take place, by which the symptoms were immediately affected, either in a favourable or an unfavourable manner. Some of our moderns have also argued in favour of these critical days, and much ingenuity has been exercised in the attempt to account for them; but a great majority of writers, and those the most respectable for their accuracy, have not been able to observe any thing of the kind. We may probably reconcile this discordance of opinion, by supposing, that the fevers which were described by the ancients, were fundamentally of the intermittent type, and that the critical days were the periods of the accession of the paroxysms, when the disease either, on the one hand, terminated fatally, or when, by the efforts of reaction, it underwent some change which induced it to assume a favourable aspect. When the body has been examined after death, morbid appearances have frequently been detected, either in the brain, the lungs, or some of the abdominal viscera, which have been usually attributed to previous inflammation, but which, we think, may with more propriety be ascribed to morbid congestion. The solids are disposed to run rapidly into a state of decomposition; and it has been imagined, although we are disposed to doubt the fact, that the body then becomes a more active source of contagion than during life.

The cure of Typhus fever has been even a more fertile source of controversy than its cause; and it must appear very embarrassing, and most discouraging to the medical student, to observe, that the very opposite plans of treatment have been recommended by persons of equal eminence, and apparently supported by an equal weight of facts and experience. It will be found, upon a more minute inspection, that this variation of plan has corresponded to the pathological hypotheses of their respective advocates; that those who attributed Typhus to debility, cured it by the exhibition of stimulants, while those who thought that it depended upon an inflammatory action, were equally successful in their practice of copious depletion. Are we then to suppose, that all our efforts are equally vain, and all our systems illusory; that the wine and brandy of the Brunonians, as well as the blood-letting and calomel of their successors, were alike inert or inappropriate? To this conclusion, we seem, in some measure, to be unavoidably reduced; but, at the same time, there are various circumstances which may tend to remove a part of the difficulty, and to reconcile what seems so palpably inconsistent. If we regard the primary cause of the disease as producing, in the first instance, a sedative effect, and consider the subsequent symptoms as depending upon a struggle between this sedative operation and the natural powers of reaction, it will follow, that the balance of the circulation may be restored either by the evacuating or the stimulating system; the former by removing a part of the circulating fluids, the latter, by giving an additional excitement to the vital powers, and thus enabling them to overcome the obstacle. The particular circumstances of the case, as depending upon the constitution of the patient, the violence of the attack, the general nature of the epidemic, and various other circumstances, external and internal, may render the one or the other of these plans preferable. We must be decided, not merely by the rapidity with which the symptoms are removed, or even by the subsequent effects upon the constitution in a few instances, but by contrasting the result of the two systems, during a long course of practice, and by minutely observing what are the immediate effects of the remedies upon the individual symptoms, and upon the respective functions.

Our general decision is, we confess, in favour of the depleting system, but, at the same time, we may remark, that in this, as in many other cases, after a long contest between the two rival systems, we find that a medium course is better than either of the two taken separately, or pushed to an extreme degree. In the cure of Typhus, we should always commence by depletions; purgatives should be administered freely, and blood-letting will often be necessary, or, at least, will promote the progress towards convalescence; the mild antiphlogistic treatment, in all its other parts, should be employed; and we may lay it down as a rule, to which there are few exceptions, that with respect to diet, temperature, and other similar points, we may, in almost every instance, safely follow the dictates of the patient's own sensations. Through the whole period of the complaint, ventilation must be assiduously attended to, and except at its very commencement, the free access of cold air will be found highly salutary to the patient himself, and very important to the welfare of those around him. The pungent heat of the body is much alleviated by frequent ablution of the surface, either by spunging it with cold fluids, or dashing water over it, in the form of what has been termed the cold affusion. This latter has even been recommended as a method of directly extinguishing the disease, when employed at an early period of it; and, in slight cases, it appears certainly to have the effect of restoring the balance of the circulation, probably in a more expeditious manner than by any other means which we possess.

When the first stage of fever is passed by, and we observe the attempts at reaction to ensue, we must be guided very much by the symptoms of the individual case; if the vital powers still appear to be oppressed; if the reaction be excessive or irregular in its effects; and, particularly, if we have symptoms which lead us to apprehend the existence of local congestion, we are still to persevere in the depleting system, which, according to circumstances, is to be either general or local; but if instead of these symptoms we have only to combat general weakness, such a plan would be absolutely injurious, and we must then have recourse to stimulants. Contrary, however, to what has been supposed, we believe that those of the mildest kind will generally be sufficient to answer our purpose, and that the more violent ones are not merely useless, but absolutely injurious; that they tend ultimately to reduce the strength of the patient; that they render him more liable to relapses; and that they impede the restoration of the digestive powers. Although it may render us liable to the imputation of weakness or inaction, we are disposed to recommend that the treatment of this part of the complaint should be chiefly palliative, and that we should rather prescribe for the purpose of removing particular symptoms, than upon the idea that we are in possession of any remedy which is universally, or even generally applicable. This remark we must especially apply to the administration of wine, a remedy which, 30 years ago, was poured into the stomach in quantities that now excite our astonishment, and from which we at least acquire a knowledge of what the human body is capable of enduring, without having its powers completely destroyed.

The next age may perhaps think that we have fallen into as great an error as that which we are now condemning, when we declare, that we do not think wine, in any respect, an appropriate remedy for Fever; states of debility may indeed occur in this complaint, when small portions of wine will be occasionally beneficial, but it should always be given with a cautious and sparing hand. Still less necessary, if possible, do we conceive cinchona to be; we think it does not possess any specific power in the cure of Typhus, and that it is even frequently injurious; in short, that direct stimulants and tonics are seldom necessary, and that the weakness is better counteracted or removed by endeavouring to restore the digestive powers, and by the proper management of air, diet, exercise, &c. than by any of the class of what have been termed febrifuges. In short, we consider Typhus to be a disease where every thing may be done by way of prevention, and where much may be accomplished in the commencement; but where medicine has but little power, when the system is once completely under its operation, and when the complaint exists in a violent degree, or has proceeded to its latter stages.

We must not conclude our remarks upon Typhus, without noticing the means that have been recommended for obviating the injurious effects of the contagion, by absolutely destroying or decomposing the infectious matter, either as it exists in the atmosphere, or as attached to articles of dress and furniture. It consists in diffusing through the air of the infected apartment certain acid vapours, of which the most active are those of the muriatic acid and of chlorine. We believe that these vapours actually possess an anti-contagious power, and that in very impure atmospheres, where ventilation has been long neglected, or cannot be easily accomplished, these fumigations may be advantageously resorted to; but, in general, we conceive them to be unnecessary, and we think that they may even be undesirable, as tending to abstract the mind of the attendants, and even of the practitioner himself, from the more essential objects of ventilation and cleanliness.*

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* This section on typhus is replete with valuable facts and judicious deductions. The observations which follow, though originally written in illustration of the nature of the continued type of fevers, may perhaps be advantageously inserted here. Fever cannot long continue without inducing debility in the heart and arteries, in common with all the other parts of the system, and the sensibility to impressions must be proportionally increased. Fever, long continued, not only wastes the power of the solids, rendering them more irritable, but by the derangement in the functions and excretions, perhaps by the action of the blood-vessels themselves upon

Sect. XVII. *Synochus Icterodes.* *Yellow Fever.*

If we have met with difficulties in our inquiry respecting the nature of Typhus, much more uncertainty will be found to attach to the species of fever which we are now going to describe—that which is epidemic in warm climates, and which has, at various times, committed such ravages in America and the West Indies, under the title of Yellow Fever.

This disease has frequently occurred in situations where it is not easy to obtain the means of making accurate observations. The extreme rapidity of its course, and the violence of its symptoms, have excited a degree of alarm, which, on many occasions, has prevented the practitioner from viewing it with the calm spirit of philosophical research; and, even where this feeling has not existed, a violence of controversial hostility, and a bigotted zeal for certain favourite hypotheses have been manifested, no less adverse to the development of truth. Almost every question respecting the yellow fever has been, and, indeed, still is, involved in much obscurity.

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their contents, and especially by the retention of those materials which should have been thrown out of the system as noxious, which in health are constantly ejected, the circulating fluids become changed and vitiated, and thereby become additional sources of irritation to the heart and arteries. Unless, therefore, by some salutary power inherent in the system itself, or by some means suggested by art, its greater irritability be diminished, or the morbid changes induced in the fluids they circulate be counteracted, these causes of fever, mutually operating upon each other, must increase, and fever be continued until the vital principle itself be totally expended. How far then, we ask, is the attention of physicians directed to these two cardinal objects in the treatment of the advanced stage of fevers? How far is their practice calculated either to impart vigour to the system, or to counteract the septic tendency of the circulating fluids, which obtains in most fevers of the continued type?

Are we not hereby led to condemn that indiscriminate and long continued use of the debilitating evacuants usually prescribed at this advanced period of fevers and febrile diseases? Is not the abstinence, too, usually enjoined by physicians in the typhoid stage of fever, to be reprobated? Are we not led, upon the same principle, on account of their adding to that waste of excitement, and the very irritation to which we have referred, to condemn the prescription of camphor, opium, musk, digitalis, and other powerful sedatives, so frequently directed in this stage of fever? We refer to the ordinary mode and quantity in which these narcotics are administered in fevers. The indiscriminate practice of purging, as advised in typhus fever, is, in our opinion, no less dangerous, by the debility it induces; the long continued use of the various preparations of mercury and antimony is also to be considered as too frequently fatal.

If the preceding principles be correctly established after the indications which arise in the first stage of continued fevers have been fulfilled, after the necessary evacuations by the lancet and other depleting means have been made, after the stomach and bowels have been cleansed, and due attention has been paid to the no less important function performed by the skin, our object should be, 1st. To preserve the natural powers of the system, and carefully to guard against every further waste of excitement; 2dly. By suitable antiseptic nourishment, and other means, including external applications as well as internal remedies, to preserve the circulating fluids from those morbid changes to which they constantly and rapidly tend, in all fevers of the continued type, especially in those arising from contagion. In this advanced or typhoid state of fever, the means of fulfilling the indications of cure are, to supply the patient with the most powerful stimuli, both diffusible and permanent; viz. the volatile alkali, æther, wine, wine whey, porter, yeast, bark, Virginia snake-root, bitters, the mineral acids, preferring each, or either of these, according to the circumstances of the case. We are aware that this practice is reprobated by many physicians as improper in this state of excitement, whatever may be the stage of the disease, or the circumstances that may have induced it. It may, however, be observed, that there is too frequently not a sufficient discrimination made between the *simple* excitement of the early stages of fever, which is characterized by the symptoms of inflammatory action, and is kept up by considerable vigour of the system, and the *complicated* excitement which appears when the powers of life are greatly exhausted, and the disease has been long protracted. A corresponding want of discrimination also appears in the practice of many: they condemn, in the last stage, those means of excitement which are injurious in the first; and they assume, in the last, the continuance of the same depleting and debilitating means that have been found useful in the first. What! it is asked, administer wine, bitters, or bark, in this quickened circulation, attended with a hot and dry skin? We answer, that in such typhoid state of the body, in this exhausted state of the vital powers, the remedies that have been enumerated are among the most effectual means of reducing that very heat of the skin, and of diminishing that increased excitement of the whole system, which are to be ascribed so frequently to the morbid sensibility of the heart and vessels to their vitiated contents: and this sensibility being counteracted, the circulation is necessarily reduced in frequency, the respiration becomes less hurried, and the heat of the system is consequently diminished.

2dly. We should be no less attentive to the state of the fluids than we are to counteract the morbid excitement of the solids: with this view, attention should be daily given to the bowels, for the purpose of evacuating their offensive contents; for these malcontents, being retained, not only in some instances become the source of irritation to the intestines themselves, producing diarrhœa, but, by their return into the mass of circulating fluids, they necessarily constitute fresh sources of febrile excitement. Evacuations from the bowels, however, are not to be obtained at that expense of the powers of the system, which the means recommended by Dr. Hamilton, of Edinburgh, are calculated to produce. Enemata, or, at most, the occasional use of small doses of rhubarb and magnesia, or some other mild aperient, are only admissible at this period of the disease. For the united purposes of preserving the surface in a perspirable state, of diminishing its temperature when excessive, and of removing the offensive materials which are excreted by the skin, the body should be regularly cleansed once or twice in the day, by ablutions of vinegar and water, applied either tepid or cold, according to the temperature of the body. Upon the same principle of correcting the state of the fluids, the nourishments directed should be exclusively of the vegetable kind; for this purpose, arrow-root, sago, tapioca, Indian or oat-meal gruel, rendered palatable by the addition of wine, &c. should be hourly administered. Due attention should also be given to the dress and bedding of the patient. For the purpose of controlling that restlessness which usually appears in the evening exacerbation, and of procuring sleep, an occasional anodyne may be administered. The following extract from a Report made to the governors of the New York Hospital, Sept. 1, 1819, affords additional evidence of the validity of these opinions of the writer. "During the period of my attendance, an ample opportunity has been afforded to the students, of observing the *typhus form* of fever, which has been unusually prevalent in this city during the last three months, and of noticing the characteristic symptoms of that type of fever as totally distinct from yellow fever. The students have also witnessed the successful use of blood-letting, and other evacuations, in the first stage, and of yeast, porter, snake-root, the vegetable acids, vegetable nourishments, and frequent ablutions of tepid vinegar and water, in the more advanced stage of that disease, instead of the *mercurial* treatment, so generally practised in many parts of the world, and especially in the United States. Indeed, I believe that the typhus fever of our country owes much of its malignity to the indiscriminate use of mercury: I say its indiscriminate use, for in some cases of fever, and in many other diseases, it is the physician's only resource. Even in typhus fever, under some peculiar circumstances, it has been prescribed with infinite benefit. Of the seventy-six cases of fever, (of which forty were cases of typhus, attended, in many instances, with symptoms of the highest malignancy) seventy-four have been cured by the means before mentioned, without a particle of mercury. Dysentery, in like manner, was treated by blood-letting, blisters, emetics, and saline cathartics, and a vegetable diet, instead of the customary treatment by calomel."

Hosack

The period when it first made its appearance—the exciting cause—the mode of its propagation—the varieties which it is capable of assuming—and the mode of cure—have each furnished matter for angry disputation. What, however, seems best established on the subject is, that a disease, at least very much resembling yellow fever, has been occasionally described as existing in different parts of the tropical regions during the last century; but it was not until about 25 years ago that it made its appearance in the western hemisphere in so violent a form as to excite general attention.

Various causes have been assigned for its appearance at this period; but the great difference of opinion which has prevailed among those who were on the spot, and had the best means of being acquainted with the facts, is of itself a strong reason for believing that the cause still remains in obscurity. The doctrine which seems to have received the support of the most enlightened physiologists is, that the cause of Yellow fever is analogous to that of intermittents, in some way connected with the decomposition of organized substances, and the formation of certain noxious miasmata; but some authors, not finding a sufficient source for these miasmata in the place where the fever has been the most prevalent, have conceived it to be contagious, perhaps the common typhus aggravated by the climate; or they have gone to the extravagant length of conjecturing, that a new specific contagion was actually generated at that period. This supposition we regard as palpably erroneous; and we farther conceive, that the facts of which we are in possession strongly tend to the conclusion, that the disease is not propagated by contagion. Generally speaking, if we may venture to hazard an opinion upon a topic confessedly so difficult of investigation, the body of evidence seems to lead to the idea, that, for the production of Yellow fever, two previous conditions are requisite, a certain state of the system, induced by the high temperature in which the body is immersed, which, in some way, operates through the medium of the biliary secretion, and a peculiar state of the atmosphere, connected with the exhalations that proceed from the soil, when acted upon by the rays of the sun, and containing a certain proportion of moisture.

The invasion of Yellow fever is, for the most part, similar to that of Typhus, except that all the symptoms are much more violent and rapid in their progress. There is great langour and weakness; pains of various parts, and especially of the head; with faintness, vertigo, and other affections, which indicate a derangement of the nervous functions. The skin becomes parched and hot; the mouth dry or clammy; the stomach and bowels lose their natural action; and all the secretions begin to assume a morbid aspect. After a space of twenty-four or thirty hours, the eyes and skin begin to acquire that yellow tinge from which the disease has acquired its specific name; nausea supervenes, and is quickly succeeded by the vomiting of a bilious matter, which sometimes appears to give a degree of relief, and is even followed by a general remission of the symptoms. This flattering calm is, however, but of short duration; the disease quickly returns in an aggravated form, and assumes the most fatal aspect. The colour of the surface becomes darker; the matter rejected by the stomach is black and grumous; all the components of the body, solids as well as fluids, tend to a state of decomposition; hæmorrhages break out from various parts; the discharges become fœtid and involuntary; and death inevitably ensues.

Although no age, sex, or condition, is exempt from the ravages of this disease, it has been observed to attack some descriptions of persons more than others. The inhabitants of cold countries, who had only lately arrived in the warm climates, were among the first sufferers. It was said, that the young, the vigorous, and the plethoric, were more obnoxious to it than the older and more debilitated; and it was remarked, that negroes were comparatively but little liable to its attacks. With respect to the time of the year in which it prevails, a considerable degree of regularity has been observed. It commences immediately after the period of the greatest summer heats, and is most violent in those seasons in which the temperature has been the highest; it continues its ravages during the autumnal months, but upon the first decided accession of cold weather, it is immediately checked. This circumstance presents a marked distinction between Yellow fever and Typhus. These diseases appear likewise to differ essentially in the nature of the constitution which they are most disposed to attack; and if we admit the Yellow fever not to be contagious, this affords a still more decisive diagnosis. When the body has been examined after death, disorganization has been discovered in many of the abdominal viscera, especially the stomach, the spleen, and the liver; their vessels have been found tinged with black blood. There have also been large extravasations; and, in some cases, the texture of the organ has appeared to be actually destroyed. Occasionally, the brain has been found much injured; and, indeed, there is scarcely any part which has not, on some occasion or other, exhibited more or less of a morbid appearance.

In so acute and violent a complaint, and one of such frequent occurrence, although we might apprehend that the means of relief would be frequently inadequate, yet we might have hoped that the effect of any particular plan of treatment would have been easily ascertained; we find, however, that even a greater difference of opinion has prevailed on this subject than on Typhus; that, in the same situation, and during the same epidemic, some practitioners were carrying the depleting system to an unheard of length, while others were plying stimulants and tonics with no less eagerness and confidence. Such excesses must be injurious, and must remain as a stigma upon the profession of medicine, which will require a long course of prudence and caution to obliterate. We believe, however, that the depleting system has completely supplanted its rival in public estimation, yet there still remain many points that are warmly contested, and respecting which we are yet without decisive facts which can serve to confirm our vacillating opinions. The most important of these respects the exhibition of calomel; this medicine has been generally recommended in Yellow fever, but in different modes, and with different intentions; by some it has been administered in combinatian with jalap and other purgatives, merely for the purpose of increasing their operation on the bowels, while other practitioners have prescribed the calomel without addition, in such a manner as to produce its specific effect upon the system, manifested by the increased flow of saliva. Very powerful evidence, and what appear very strong facts, have been adduced in favour of each of these plans, so as to render it extremely difficult to decide upon the question; upon the whole, we should be disposed to recommend, as a general principle, that the calomel be administered with a view to its purgative operation; but we do not think it impossible that, in certain stages of unusual oppression or torpor of the system, some advantage may be obtained by its general stimulating effect. The quantities of calomel that have been given in this way are almost incredible, and may suggest the same remark that we made above, respecting the way in which wine was formerly prescribed in Typhus. Upon the whole, the balance of evidence in Yellow fever would lead us to begin with copious bleeding, and afterwards steadily to persevere with purgatives, of which calomel should form a principal ingredient; we must also pursue the general antiphlogistic system in its various parts, and carefully attend to ventilation and the application of external cold. In the latter stages, stimulants and excitants may be tried, but it is doubtful whether, in this period of the disease, the art of medicine can afford any prospect of benefit. We find, unfortunately, that the means of checking or cutting short the disease in its earlier stages, which have been sometimes found efficacious in Typhus, such as the cold affusion, appear to have no power over Yellow fever, nor are we to expect any advantage to result from the use of fumigations, as we suppose that it is not propagated by specific contagion.

SECT. XVIII. *Pestis. Plague.*

The remaining species of Febris which we have to describe is, that to which the name of Pestis has been exclusively applied, as characteristic of its peculiar virulence. Although it has been known from a remote period, and has at all times continued to spread its ravages in different parts of Europe, yet there is, perhaps, still more uncertainty respecting its nature, and the different circumstances connected with its production and propagation, than even respecting the Yellow fever itself. The prevailing opinion is in favour of its being contagious, and a system of strict police has been established by the governments of all civilized countries on this principle, to prevent its communication and progress; but it would appear that the laws of the contagion of Plague are considerably different from those of Typhus, so much so, indeed, that some authors, who have written from their own experience, have not scrupled to deny altogether its contagious nature. We conceive, however, that the evidence is decidedly in favour of the affirmative side of the question, but the sphere of infection appears to be much more limited, in proportion to the violence of the disease, than in Typhus. It resembles Typhus in being more certainly propagated by means of the miasms which attach themselves to clothes or other articles of furniture, than merely by the infection which is diffused through the atmosphere which surrounds the patient, and in the same manner, it is found to be so much diluted by free ventilation, and by attention to cleanliness, that the disease may be almost certainly prevented from propagating itself. There is strong reason to believe that the Plague is capable of being produced by other causes besides contagion from the bodies of those previously diseased, and it farther seems, that the heat of the weather, or some peculiar condition of the atmosphere, which is not appreciable by the senses, either actually generates the disease, or so predisposes the body to receive it, that it is produced by the very slightest application of the exciting cause.

In the mode of its invasion and its general character Pestis very much resembles the most violent forms of Typhus, so that, in a great number of cases, it would be almost impossible to distinguish between them, were it not for the occurrence of one circumstance, which may be regarded as a pathognomonic symptom of Plague, the formation of tumours in the absorbent glands, which appear soon after the commencement of the disease, and generally proceed to suppuration. How far they ought to be regarded as critical evacuations, or what relation they bear to the constitutional affection, is scarcely yet ascertained; but some curious, although very hazardous experiments, which have been lately performed, appear to prove that the matter discharged from these tumours is not capable of generating the disease, even when inserted below the skin by inoculation. A farther circumstance in which the Plague differs from Typhus, is the season of the year when it occurs; it rages with the greatest violence in the hottest weather, and is completely extinguished by the cold of winter, even in the climate of the south of Europe; whereas it is well known that there is no exception of this kind with respect to the most malignant fever of this country.

There is still considerable uncertainty respecting the proper treatment of Plague; probably in the early stages the depleting and antiphlogistic plan is what ought to be pursued, but we have not had the same experience of the length to which it may be pushed, as we have with respect to the Yellow fever. It is generally admitted that the glandular tumours ought to be brought to suppurate as quickly as possible, and that when this event takes place, the symptoms are mitigated. It is to be feared, that in this disease, as in Typhus and Yellow fever, after the first stage is passed by, and is succeeded by imperfect reaction, or by torpor of the vital powers, but little can be expected from the operation of medicine, except in the way of relieving particuler symptoms, or in supporting the strength by moderate stimulants, when we have to combat the state of exhaustion which supervenes as the consequence of the disease, after the febrile action is extinguished. It is doubtful what degree of efficacy the different kinds of fumigations possess in destroying the contagion of the Plague, but it is to be feared that they have not the same power in this case as in Typhus. With respect to the various antidotes or specifics that have, from time to time, been held out with such excessive commendations, it is scarcely necessary to observe, that they are all of them mere impositions upon the credulity of the public.

Before we conclude our remarks upon the genus of Febris, we shall point out, in a summary manner, and in the form of queries, a few of the points respecting them which still remain the subject of doubt or controversy. Is Typhus always produced by contagion; if not, what are the other exciting causes? Can it be generated by filth, want of food, imperfect ventilation, &c.? Does the proper Typhus exist between the tropics? what relation does it bear to the Yellow fever or to the Plague? Are the putrid exhalations from decomposing animal matter ever the cause of Typhus, or of any other specific fever? Is the fever that ensues after a season of scarcity the proper Typhus, propagated by contagion, although originating from other causes? Are the Yellow fever and the Plague contagious? If contagious, are they ever produced by other causes except contagion? What connexion is there between the proximate cause of fever and inflammation? Is the state of congestion which the viscera exhibit after fever to be regarded as the cause, or the consequence of the disease? What relation does the febrile action in its regular stages bear to debility? What effect does climate, and especially a high temperature, possess, in modifying the symptoms of Typhus? What connexion has the Yellow fever with the intermittents of temperate climates? Has the Typhus of this country actually become milder of late years; or does this greater mildness of the individual cases depend upon the improved habits of the people, with regard to ventilation and cleanliness?*

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* In the present state of medical science it is not possible to solve the queries proposed in the preceding paragraph. In Great Britain, in a particular manner, we look for the prevalence of the various forms of typhus fever; and, in her writers, do we find the most luminous views as to the nature and character of the disease. Nevertheless, from our own observation and experience, we hardly think it a subject of doubt or controversy that typhus is produced by other agents than contagion. Though this may be considered its most general cause, yet our own experience is sufficient to convince us that this disorder may be generated by filth, want of food, imperfect ventilation, and the like. As to the question, are the putrid exhalations from decomposing animal matter ever the cause of typhus, or of any other specific fever, we are not aware of any facts extant, which warrant an affirmative to the question. Are the yellow fever and plague contagious? We think the evidence abundantly sufficient for ever to settle this question. The writer in the text does not appear to have made use of the facts concerning the contagious nature of the yellow fever and plague, as recorded by Chisholm, Blane, McGregor, Pym, Fellowes, and other members of the Army Medical Board of Great Britain, nor with the history of the extension of yellow fever in Cadiz, and the numerous communications on the disease as it has prevailed in this country. See the American Medical and Philosophical Register, New York, 1810-14. See also Transactions of the College of Physicians of Philadelphia, and Facts and Observations, and additional Facts and Observations, published by the same association. That the yellow fever is, like small pox, contagious under all circumstances, is not contended; but that in a foul confined apartment, a crowded population, as on sea board, or in a garrison, the disease, with all its striking characteristics, is communicable from one person to another, is confirmed by undoubted testimony.—With regard to the contagious character of plague, it is sufficient to refer the candid reader to the single fact, that this disease has been communicated by inoculation, as we are assured upon the most respectable authorities. See Wilson, Expedition to Egypt; McGregor, Medical Sketches; Desgennetts, Histoire Medical de l'Armée d'Orient; Francis, letter on Febrile Contagion, Colvert, in Medico-Chirurgical Transactions of London. Query, Do not the facts concerning the malignant and contagious nature of yellow fever and plague authorise the government of the United States to legislate on the subject, and do they not point out the expediency of their providing a general system of quarantine regulations, calculated to guard against the introduction of these diseases, and which system of laws should be alike operative in all our sea-ports?—We believe that both plague and yellow fever may be produced by other causes than contagion. It would seem that the typhus of Great Britain has actually become milder of late years, but that this mildness is owing chiefly to the improved habits of the people with regard to ventilation and cleanliness; we believe that much has been accomplished by the establishment of fever wards and houses of recovery, as originally proposed by Haygarth and the late Dr. Ferriar.

HOSACK.

(*Continued in Vol. XIII.*)

GENERAL EXPLANATION OF THE PLATES BELONGING TO VOLUME TWELFTH OF THE AMERICAN EDITION OF THE NEW EDINBURGH ENCYCLOPÆDIA.

PLATE CCCXLVII.

Contains,

1. The Lighthouse called the Tour de Cordouan on the coast of France.
2. A Section of the Eddystone Lighthouse on the coast of England.
3. A Section of the Lighthouse of Kilwarlin on the coast of Ireland.
4. A Section of the Bell Rock Lighthouse on the coast of Scotland.

PLATE CCCXLVIII.

Contains,

1. A View of the Lighthouse of Corunna.
2. A View of the Lighthouse of Genoa.
3. A View of the Lighthouse of Naples.
4. A View of the Lighthouse of Ramsgate.
5. A View of the Leading Lights of Tay.
6. A View of the Lighthouse of Dublin.

PLATE CCCXLIX.

Contains Plans, Elevations, and Sections of the Lighthouse on Inchkeith, in the Firth of Forth, and a Section of the Light-room, a Section of a Reflector, and a Plan of the Reflector Frame.

PLATE CCCL.

Figs. 1. 2, 3, 4, and 5, represent the detached parts of Bramah's Lock, according to the last and most approved construction.

Fig. 6. Shews the form of the Key.

Fig. 7. Represents the Tumbler Lock invented by Mr. Robert Baron.

Figs. 8. and 9. Represent the contrivance called a Fly Tumbler, first introduced by Mr. Baron as an addition to his Lock.

Figs. 10. and 11. Represent an ingenious Lock, invented by Mr. Thomas Ruxton of Dublin.

Figs. 12, 13, 14, and 15. Represent the Patent Detector Lock, invented by Mr. Jeremiah Chabb of Portsea.

Figs. 16, 17. Represent a Lock, called a Combination Padlock.

PLATE CCCLI.

Contains various figures illustrative of the article on Magnetism.

Figs. 4 and 5. Represent two forms of the Dipping Needle.

Fig. 18. Represents Coulomb's Torsion Balance, as applied to Magnetism.

PLATE CCCLII.

Contains various figures illustrative of the article Magnetism.

Figs. 32. 33. Shew the method of arming Magnets.

Fig. 36. Shews the method of making Artificial Magnets employed by Duhamel and Antheaume.

Figs. 37, 38. Shew Mr. Michell's method of making Artificial Magnets by the double touch.
Fig. 39. Shews Æpinus's modification of the method of double touch.
Figs. 40, 42. Shew Coulomb's method of making Artificial Magnets, as deduced from the preceding methods.
Figs. 41, 43, 44. Shew Biot's improved method of making Artificial Magnets.
Fig. 45. Shews Baptista Porta's method of measuring the law of Magnetic Action.
Fig. 51. Shews Coulomb's method of ascertaining that all Bodies whatever are Magnetic.

PLATE CCCLIII.

The forty-eight Figures, in the *six* following Plates, are illustrative of the article Mazology.
Fig. 1. Orang-Outang.
Fig. 2. Little Lion Monkey.
Fig. 3. Common Baboon.
Fig. 4. Howler.
Fig. 5. Slow Lemur.
Fig. 6. Colugo.
Fig. 7. Vampire Bat.
Fig. 8. Polar Bear.

PLATE CCCLIV.

Fig. 9. Ichneumon.
Fig. 10. Ferret.
Fig. 11. Lion.
Fig. 12. Lioness.
Fig. 13. Tiger.
Fig. 14. Common Lynx.
Fig. 15. Civet.
Fig. 16. Common Hyena.

PLATE CCCLV.

Fig. 17. Fenner.
Fig. 18. Wolf.
Fig. 19. Jackall.
Fig. 20. Common Opossum.
Fig. 21. Wombat.
Fig. 22. Phalanger.
Fig. 23. Kanguroo.
Fig. 24. Flying Squirrel.

PLATE CCCLVI.

Fig. 25. Jerboa.
Fig. 26. Alpine Marmot.
Fig. 27. Crested Porcupine.
Fig. 28. Pangolin.
Fig. 29. Great Ant-eater.
Fig. 30. Three-toed Sloth.
Fig. 31. Long-nosed Tapir.
Fig. 32. Single-horned Rhinoceros.

PLATE CCCLVII.

Fig. 33. Hippopotamus.
Fig. 34. Dromedary.
Fig. 35. Musk.
Fig. 36. Pigmy Musk.
Fig. 37. Stag.
Fig. 38. Roe.
Fig. 39. Rein Deer.
Fig. 40. Giraffe.

PLATE CCCLVIII.

Fig. 41. Nylghau.
Fig. 42. Gnu.
Fig. 43. Chamois.
Fig. 44. Ibex.
Fig. 45. Musk Ox.
Fig. 46. Zebra.
Fig. 47. Maned Seal.
Fig. 48. Morse.

PLATE CCCLIX.

Contains various Diagrams illustrative of the Doctrines of Statics.

PLATE CCCLX.

Contains various Diagrams illustrative of the Doctrines of Statics.

PLATE CCCLXI.

Contains Diagrams illustrative of the Mechanical Powers.
Fig. 8. Represents the common Steelyard.
Fig. 9. Is the Danish Steelyard.
Figs. 10—17. Represent Pulleys of various kinds.
Figs. 18, 19. Represent Pulleys called Spanish Bartons.

PLATE CCCLXII.

Contains Diagrams illustrating the Mechanical Powers.
Fig. 1. Is the Wheel and Axle.
Fig. 5. Is a System of Toothed Wheels, in which the teeth are prolongations of the radius.
Fig. 6. Another System of Toothed Wheel, in which the Teeth are perpendicular to the radius.
Fig. 7. Represents a Pinion called a Lantern.
Fig. 18. Represents Hunter's Double Screw.

PLATE CCCLXIII.

Contains various Diagrams illustrating the Theory of the Rope Machine, the Oscillation of Pendulums, the Theory of Rotatory Motion, the Collision of Bodies.

PLATE CCCLXIV.

Figs. 1—4. Are Diagrams illustrating the Theories of the centres of Oscillation, Gyration, and Percussion.
Figs. 5, 6. Shew Coulomb's Apparatus for experiments on Torsion.

Fig. 7. Represents Coulomb's Apparatus for experiments on the Flexion of Plates of Metal.

Fig. 8. Represents a Walking Crane.

Fig. 9. Shews the Vanes, &c. of a Windmill.

Fig. 10. Represents Smeaton's enlarged Sails.

Fig. 11. Shews Mr. Beatson's Horizontal Windmill Sails.

Figs. 12—17. Are Diagrams, &c. for illustrating Mr. Buchanan's Horizontal Windmill.

Figs. 18—20. Are Diagrams for explaining the Theory of the Teeth of Wheels.

PLATE CCCLXV.

Fig. 1—13. Are Diagrams for illustrating the Theory of the Teeth of Wheels, whether cylindrical or conical; the Wipers of Stampers, &c.

Figs. 14, 15, 16. Represent the method of communicating motion to wheels by means of chains of different kinds.

Fig. 17. Represents twelve different chains used in machinery.

Fig. 18. Represents the Lever of Lagaroust.

Fig. 19. Represents the Common Crank.

Fig. 20. The Double Crank.

Fig. 21. The Triple Crank.

Fig. 22. The Changeable Crank, in which the radius is variable.

Fig. 23. Represents Hooke's Single Universal Joint.

Fig. 24. Shews Hooke's Double Universal Joint.

Fig. 25. Represents the Contrivance called the Sun and Planet Wheel, contrived by the late Mr. Watt for converting a reciprocating into a rotatory motion.

Fig. 26. Shews the Ball and Socket.

Fig. 27. Is a contrivance used for changing a circular motion in one plane, into a circular motion in any other plane.

Fig. 28. Is a contrivance invented by M. Camus for moving Sieves, by which a circular alternating motion is changed into another of the same kind.

Figs. 29, 30. Contain other contrivances for the same purpose.

PLATE CCCLXVI.

Contains numerous pieces of mechanism for converting one motion into another of a different kind.

Figs. 1, 2. Represent methods of converting a rectilineal continuous motion into a circular alternating motion.

Fig. 3. Is a contrivance for changing a rectilineal continuous motion into a rectilineal alternating motion.

Figs. 4—15. Contain various contrivances for converting a continuous circular motion into a rectilineal alternating motion.

Figs. 16—21. Contain various pieces of mechanism for converting a continuous circular motion into an alternating circular motion.

Figs. 22—25. Contain various contrivances for changing a rectilineal alternating into a circular alternating motion.

PLATE CCCLXVII.

Figs. 1, 2. Represent a Plan and Section of Prony's Condenser of Forces.

Figs. 3, 4. Represent Mr. Samuel's apparatus for regulating the action of Horses in Thrashing Machines.

Fig. 5. Shews the application of Mr. Watt's Conical Pendulum for regulating the velocity of Millstones.

Figs. 6, 7. Represent Wolff's Substitute for a Fly.

Fig. 8. Represents Mr. Featherstonehaugh's contrivance for supplying the place of Counterweights.

Fig. 9. Represents another kind of Counterweight.

Fiw. 10. Shews Coulomb's idea of the structure of the surface of wood.

Fig. 11. Represents the same surfaces when in the act of moving over one another, but the friction not overcome.

Fig. 12. Shews the same surfaces when moving upon one another, and the friction overcome.

Fig. 13. Shews his idea of the surfaces of metals.

Fig. 14. Represents Coulomb's apparatus for measuring the friction and rigidity of ropes.

Fig. 15. Is Coulomb's apparatus for measuring the friction of pivots.

Fig. 16. Shews Gottlieb's anti-attrition axletree.

Fig. 17. Represents Mr. Gamett's method of applying Friction Rollers.

Fig. 18. Shews Vaucanson's contrivance for dispensing with Pivots.

Fig. 19. Represents M. Gaston Thiville's method of diminishing the Friction of Axles.

PLATE CCCLXVIII.

Fig. 1, 2, 3, 4, 5, 6. Represent Mr. Atwood's Machine for illustrating the doctrines of Dynamics.

Figs. 7, 8. Represent M. Fortin's improvement upon it, or new detent.

PLATE CCCLXIX.

Fig. 1. Represents Mr. Smeaton's apparatus for experiments on Rotatory Motion.

Fig. 2. Is Smeaton's apparatus for experiments on Windmill Sails.

Fig. 3. Is a machine in which all the mechanical powers are united.

Fig. 4. Represents a machine for illustrating the theory of a wedge.

Fig. 5. Is an apparatus for shewing the effects of the centrifugal force on the form of the earth,

Fig. 6. Is an apparatus for representing the composition of Forces.

Fig. 7. Shews a machine for trying the strength of materials.

Fig. 8. Represents Gravesende's apparatus for measuring the elasticity of metallic Plates.

Figs. 9, 10, 11, 12. Represent Dr. Brewster's Teinometer for measuring Elasticities.

PLATE CCCLXX.

Fig. 1. Represents Coulomb's apparatus for his experiments on Friction.
Fig. 2. Is a side view of the same, with a view of the Steelyard for gaining great pressures.
Fig. 3. Shews Hachette's Dynamometrical Machine.
Fig. 4. Explains Hachette's Portable Dynamometrical Machine.
Figs. 5, 6, 7. Represent Prony's apparatus for converting continuous motion into reciprocating ones.
Figs. 8, 9. Shew Betancourt's contrivance for the same purpose.
Fig. 10. Is Prony's apparatus for Unyoking Horses.
Fig. 11. Shews Berthelot's method of converting a reciprocating into a rotatory motion.
Figs. 12, 13. Represent a Pulley with a variable radius.

PLATE CCCLXXI.

Fig. 1. Shews Bonesnel's apparatus for coiling ropes round Drums.
Figs. 2, 3, 4. 5. Represent the method of producing continuous motions by means of weights in theatres.
Fig. 6. Represents Camus's Pile-Engine.
Figs. 7, 8. Is another Pile Engine.
Figs. 9, 10, 11. Represent Vauloue's Pile-Engine.
Fig. 12. Represents Bunce's Pile-Engine.

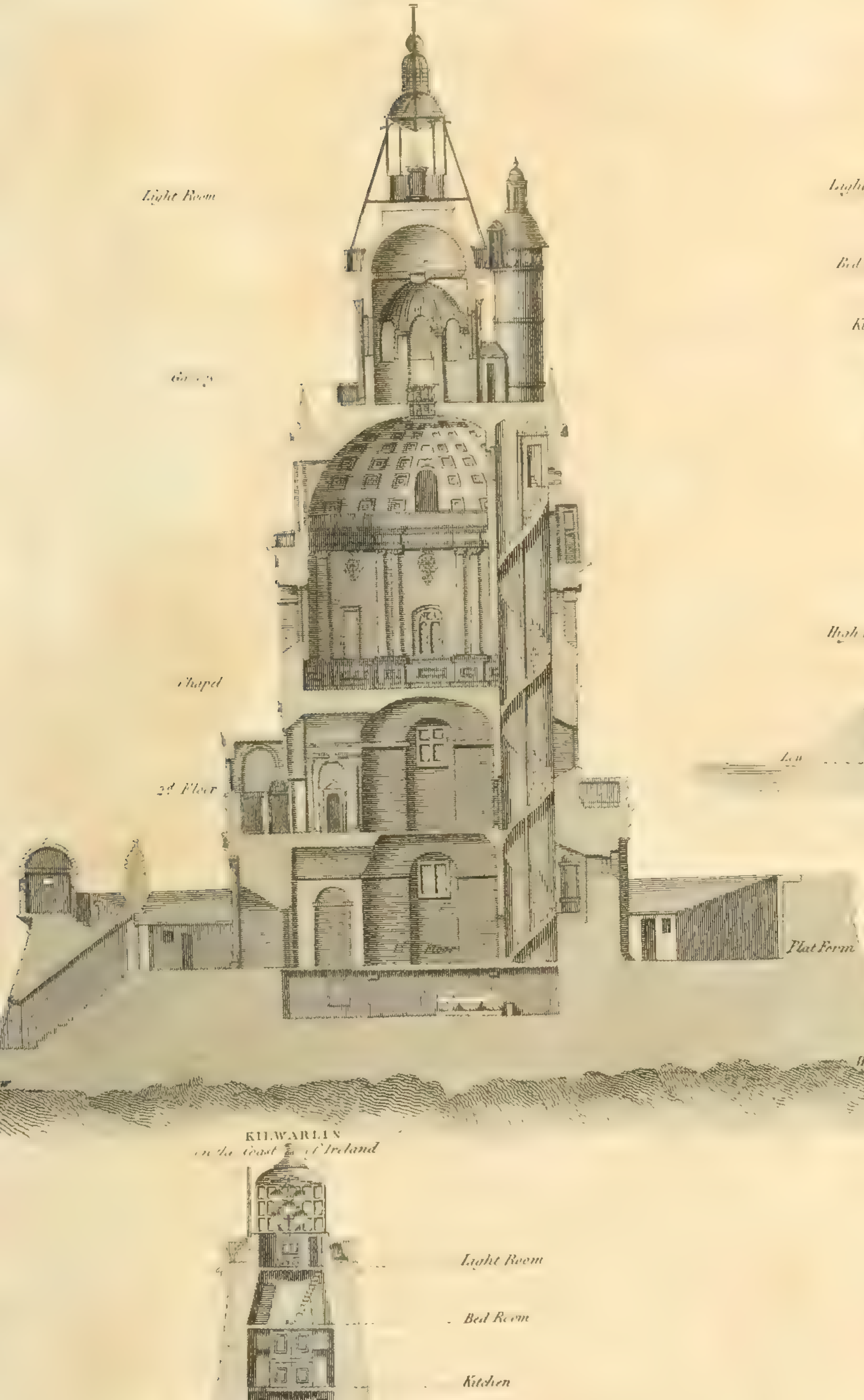
END OF VOLUME TWELFTH.

William Brown, Printer, Philadelphia.

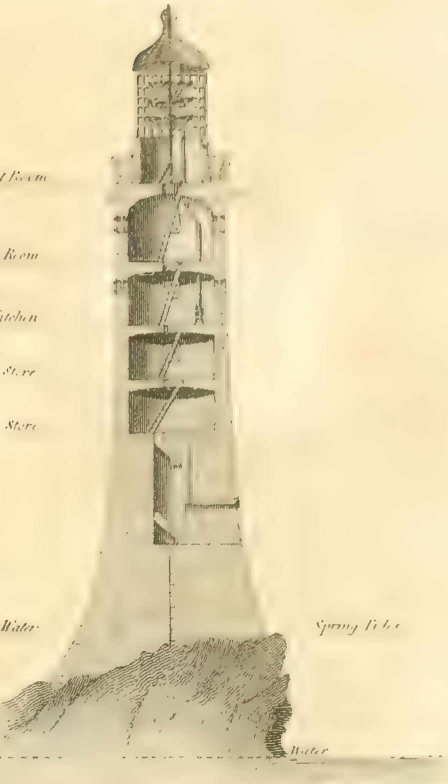
LIGHTHOUSE.

PLATE CCCXLVII.

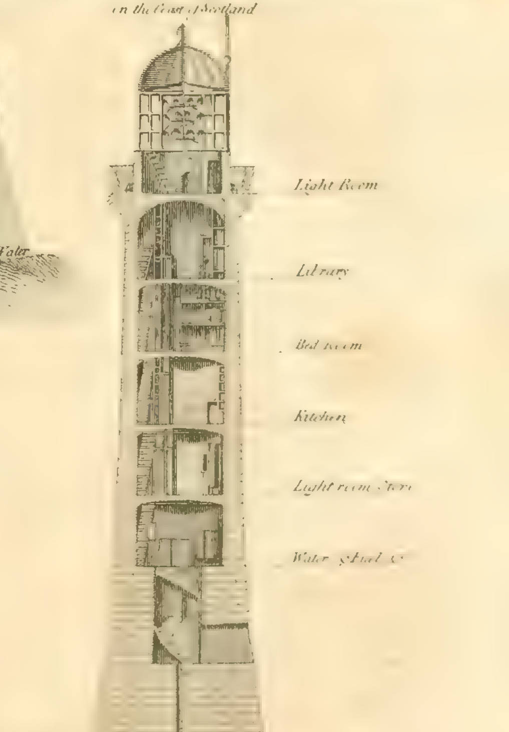
TOUR DE CORDUAN
on the Coast of France



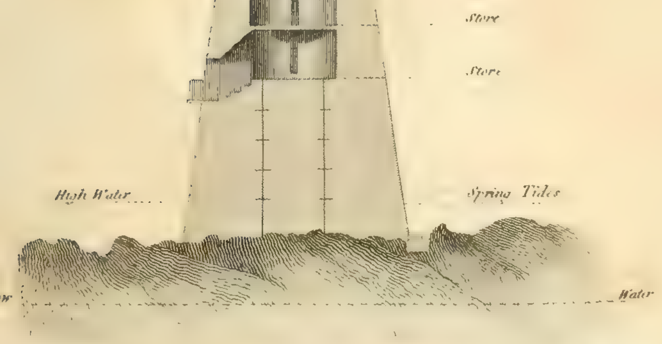
EDDYSTONE
on the Coast of England

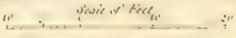


BELL ROCK
on the Coast of Scotland



KILWARLIN
on the Coast of Ireland

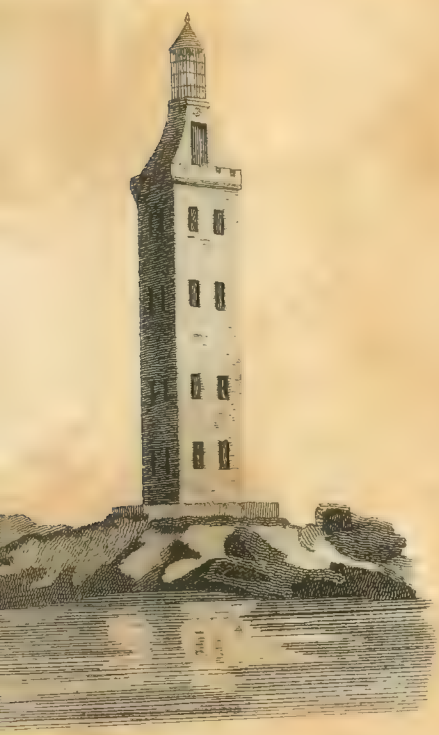




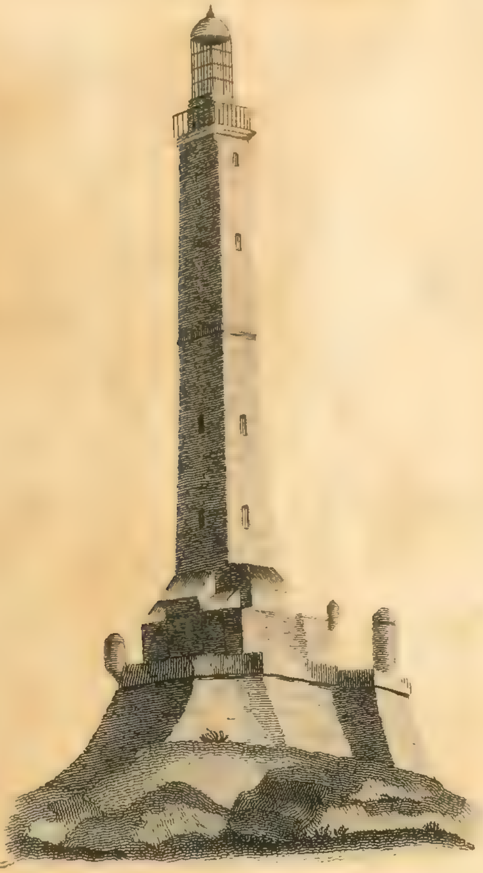
LIGHT HOUSE.

PLATE CCCXLVIII.

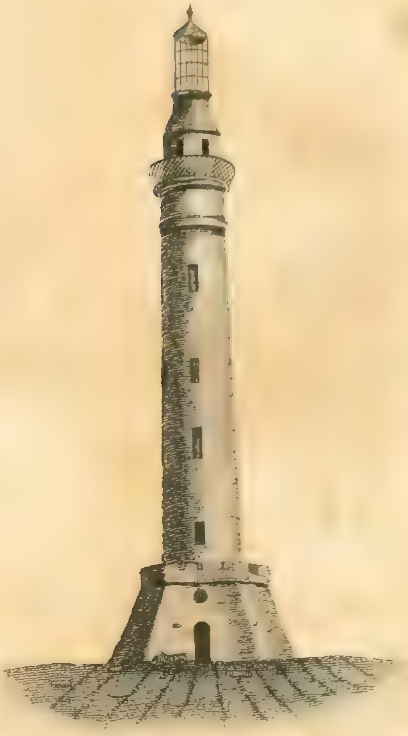
CORRUNNA.



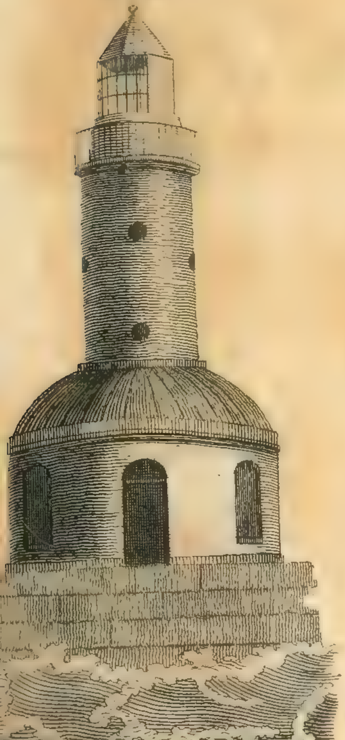
GENOA.



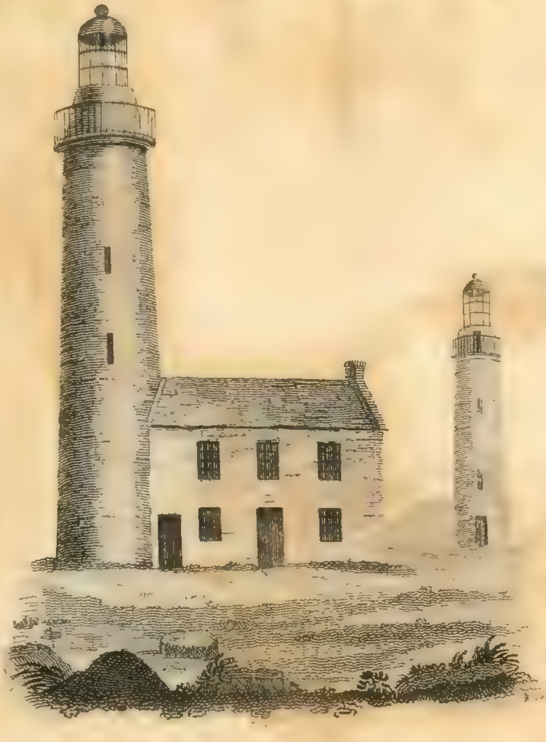
NAPLES.



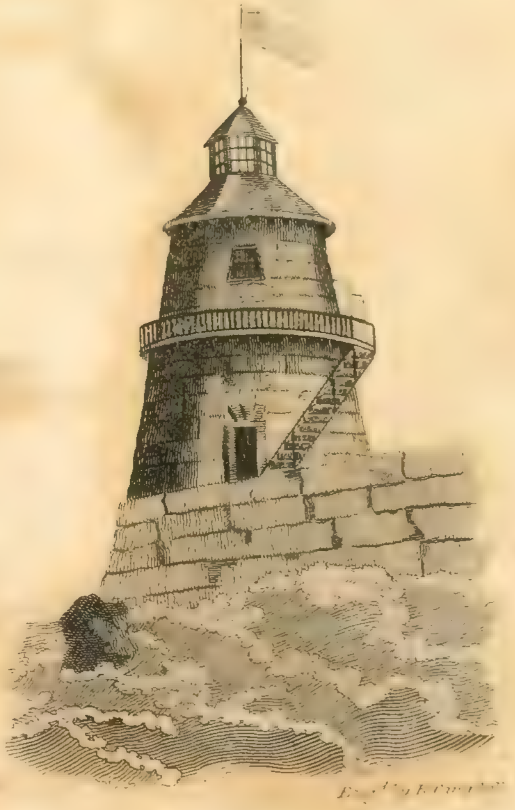
RAMSGATE.



LEADING LIGHTS of TAY.



DUBLIN.



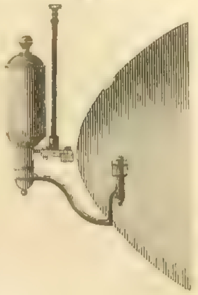
Eng.d by Kirkwood

LIGHTHOUSE.

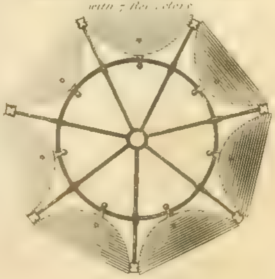
PLATE CCCXLIX.

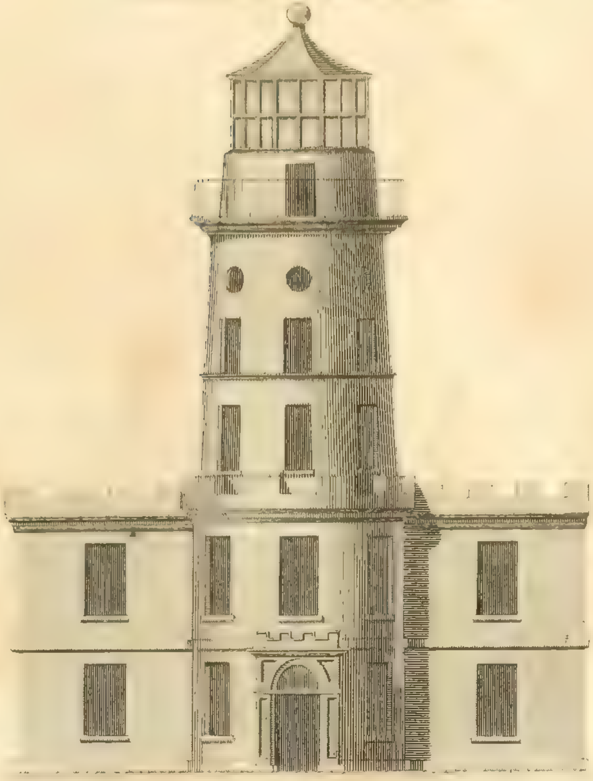
INCHKEITH LIGHT HOUSE in the FIRTH of FORTH

SECTION of a REFLECTOR

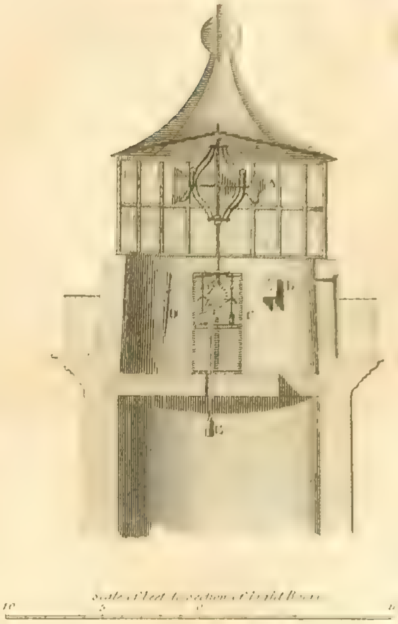


PLAN of REFLECTOR FRAME
with 7 Reflectors

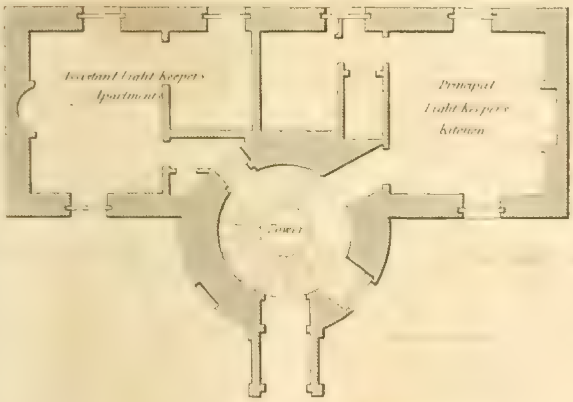




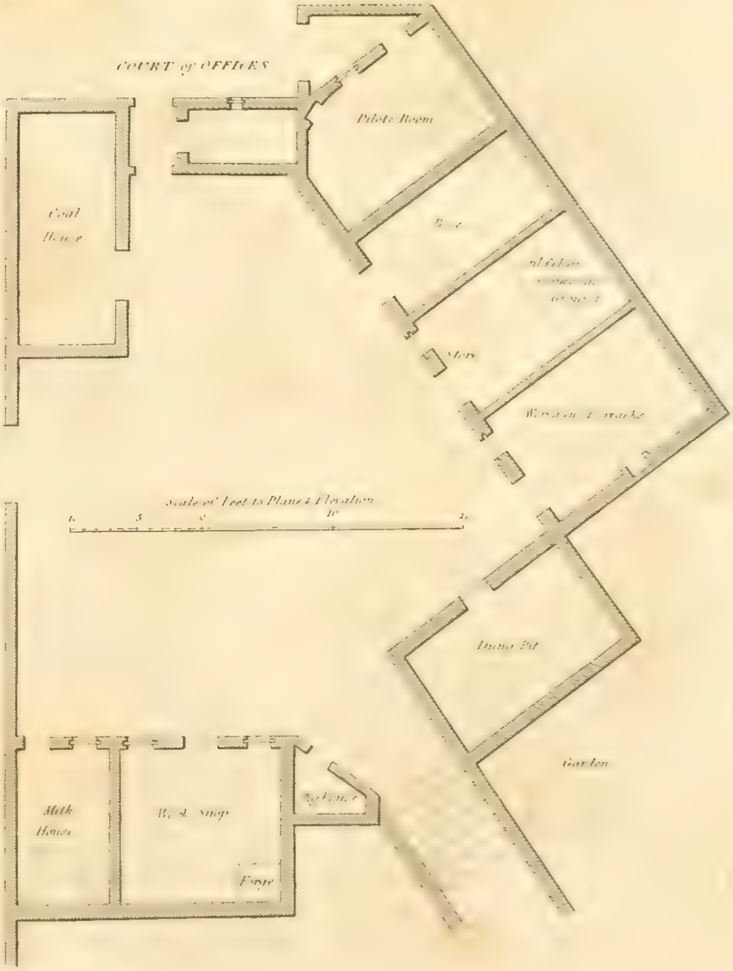
SECTION of LIGHT ROOM



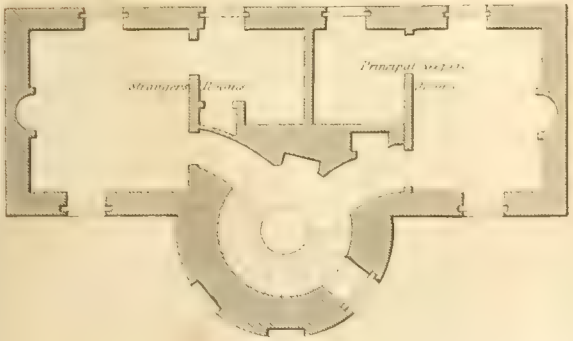
GROUND FLOOR


Assistant Light Keeper's Apartments
Principal Light Keeper's Kitchen
Tower

COURT of OFFICES



2D FLOOR



LOCKS.

PLATE CCCL.

BRAMAH'S

Fig. 1.

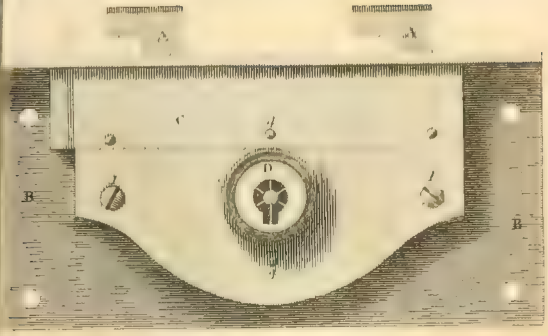
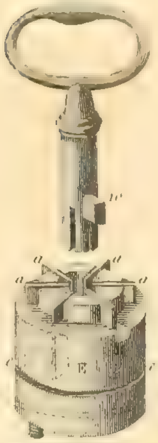


Fig. 6.



BARON'S

Fig. 7

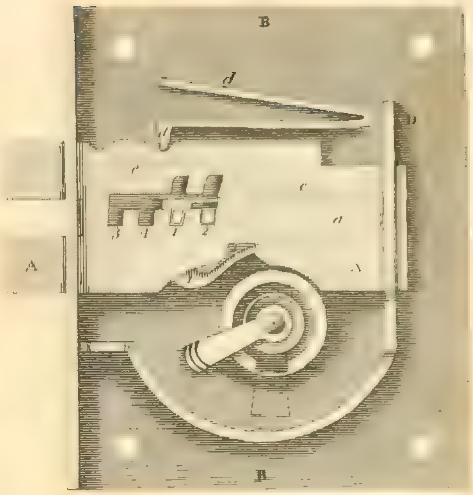


Fig. 4.

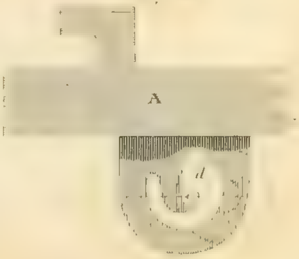


Fig. 3.

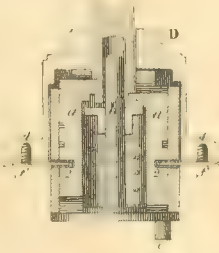


Fig. 2.

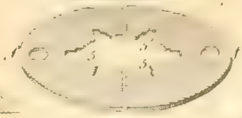


Fig. 5.

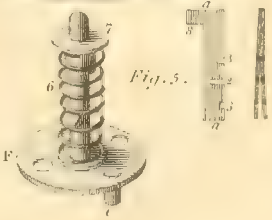
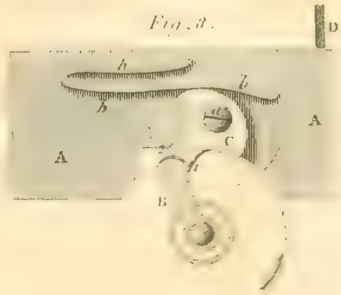
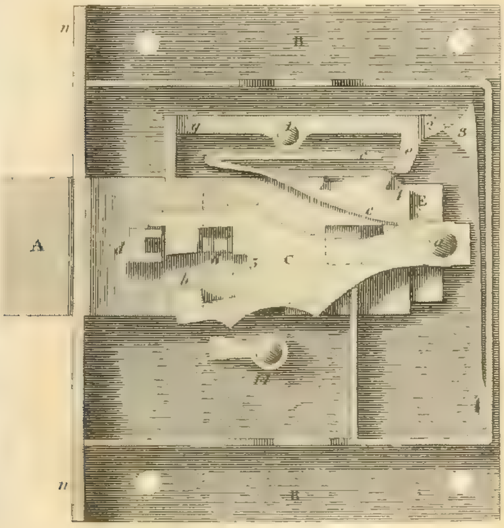


Fig. 8.



CHUBB'S

Fig. 12.



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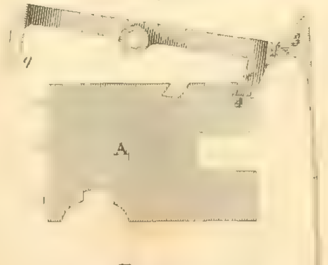


Fig. 9

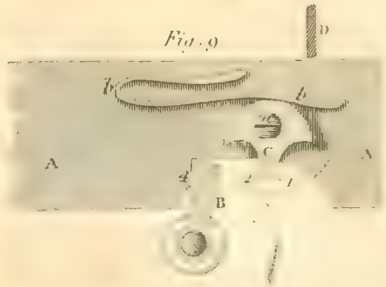


Fig. 14.

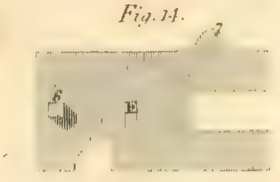
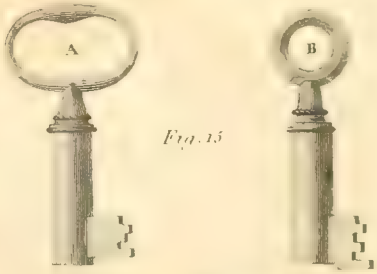
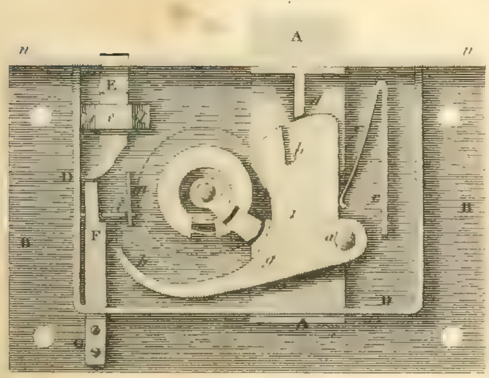


Fig. 15



HEATON'S

Fig. 10.



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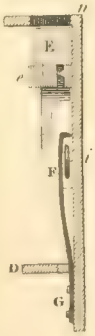


COMBINATION LOCK.

Fig. 17.

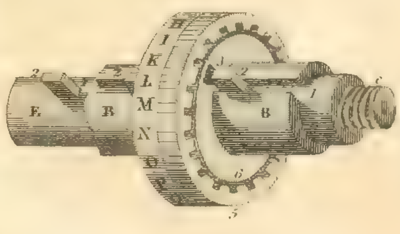
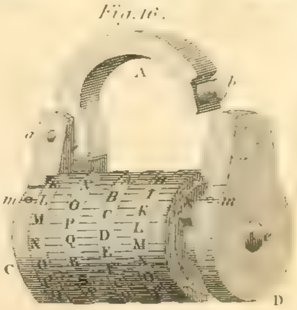


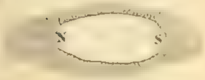
Fig. 16.



J. Lowry sc.

MAGNETISM. PLATE CCCLI.

Fig. 1.



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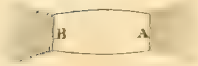


Fig. 3.

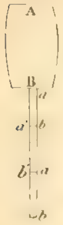


Fig. 4.

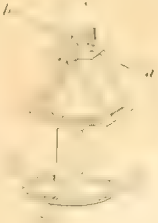


Fig. 5.

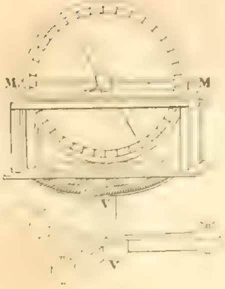
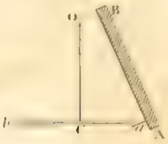


Fig. 6.



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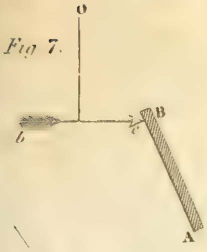

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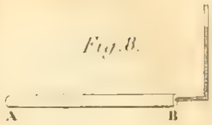

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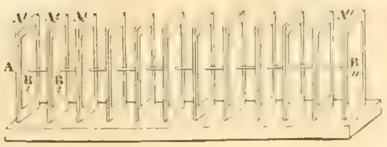

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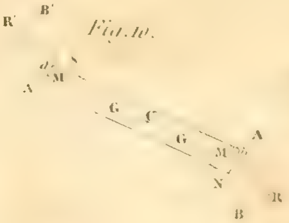

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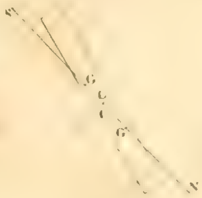

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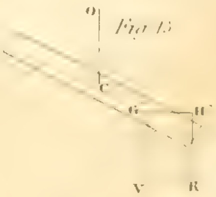

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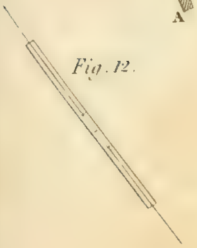

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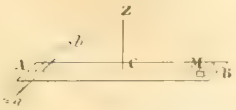

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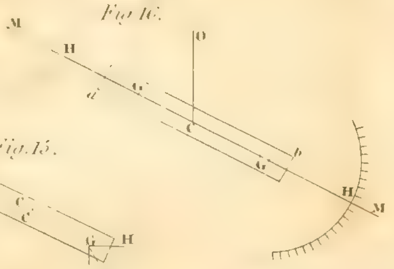

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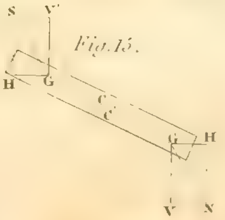

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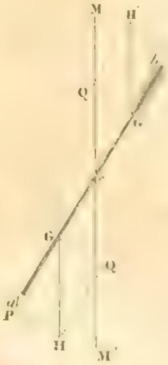

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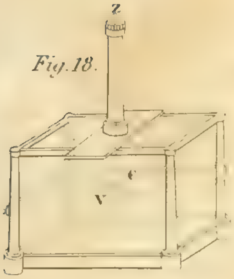

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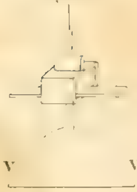


Fig. 20.

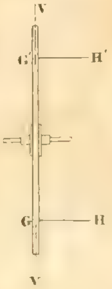


Fig. 21.

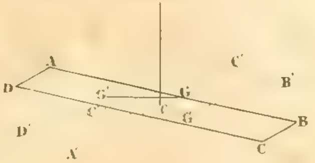


Fig. 23.

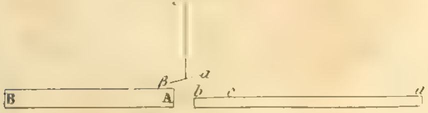


Fig. 22.

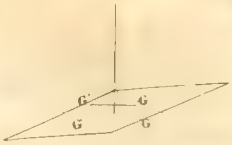
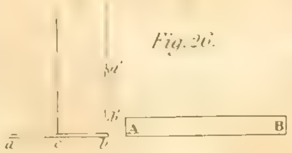


Fig. 26.



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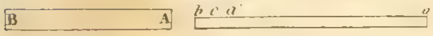

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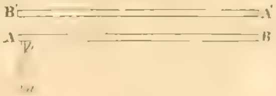

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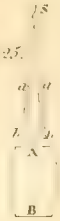

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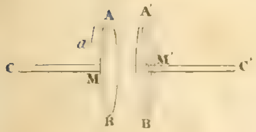

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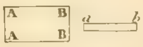

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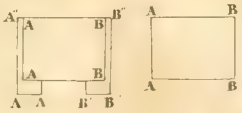
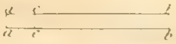


Fig. 31.



MAGNETISM.

PLATE CCCLII.

Fig. 32.

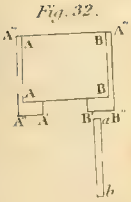
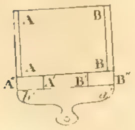


Fig. 33.



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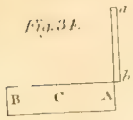

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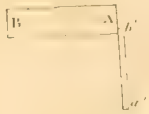

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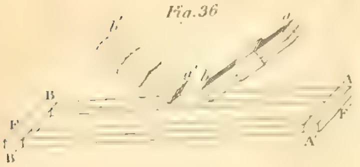
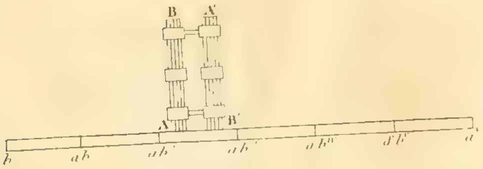


Fig. 37.



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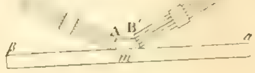

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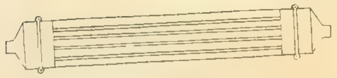


Fig. 41.

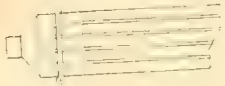
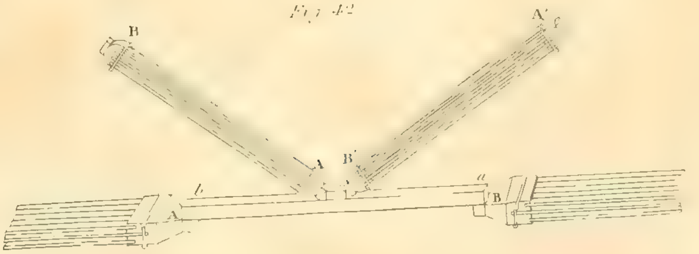


Fig. 42.



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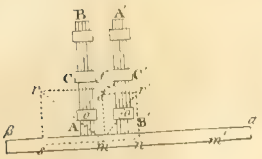

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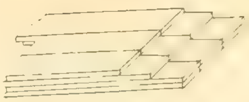

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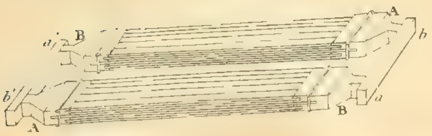

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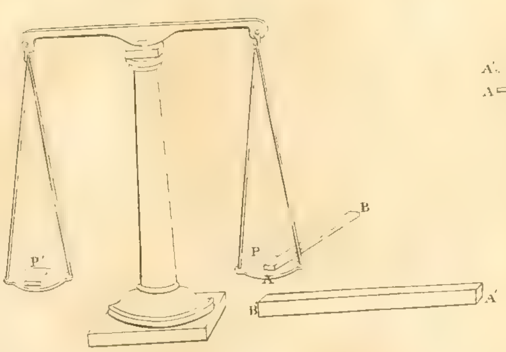

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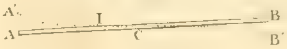

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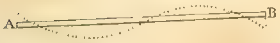

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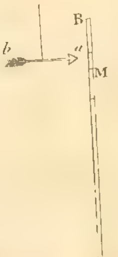

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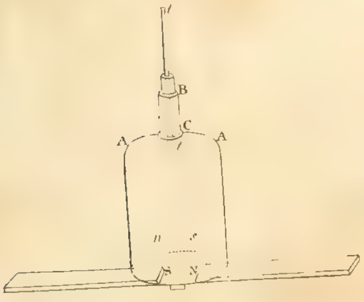

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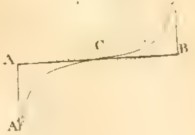

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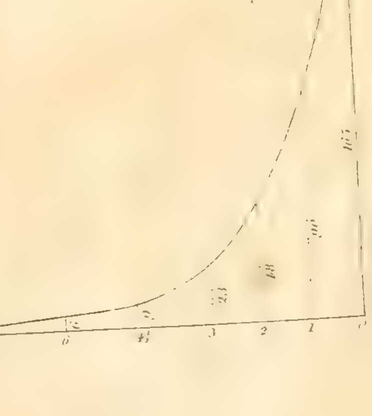

H. Anderson sc.

MECHANICS.

PLATE CCCLIX.

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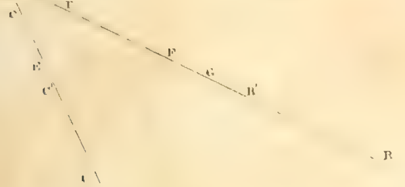

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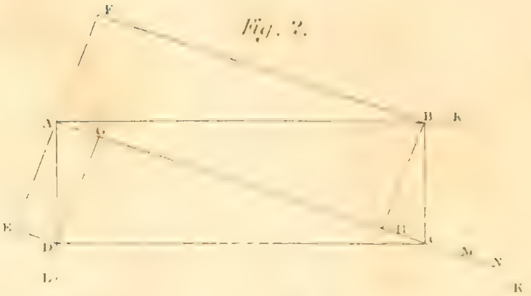

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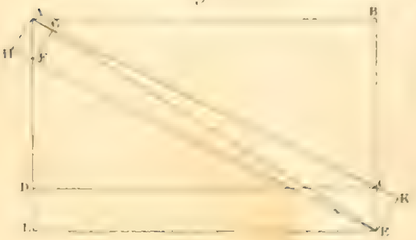

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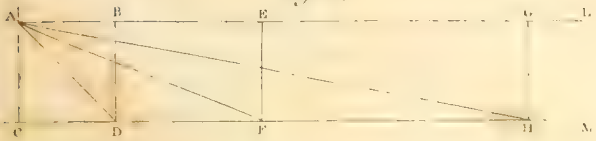

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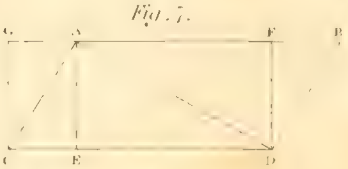

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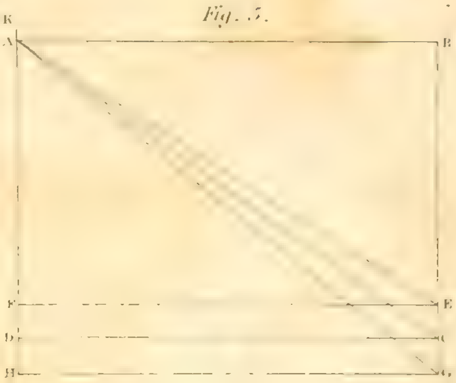

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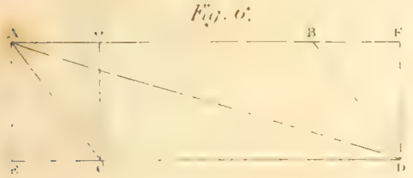

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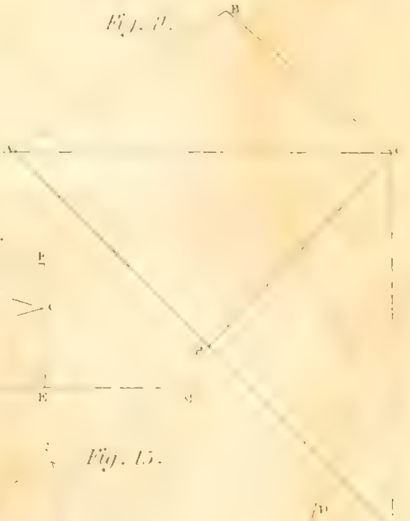

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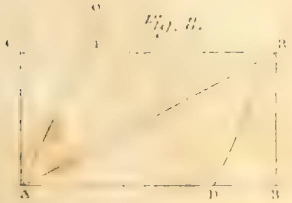

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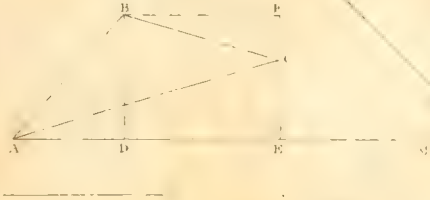

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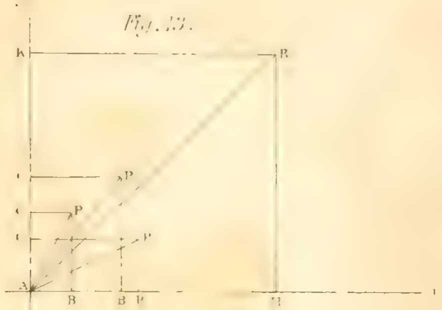

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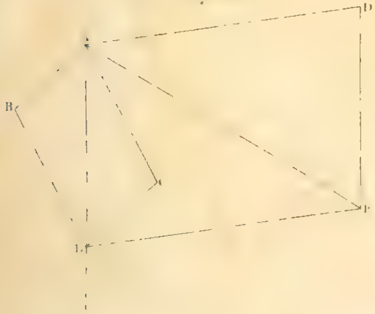

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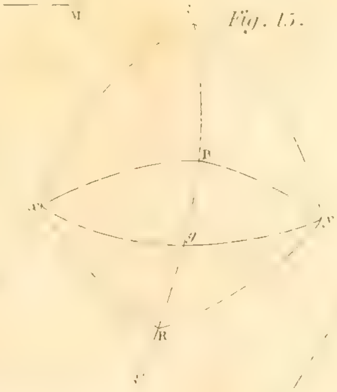

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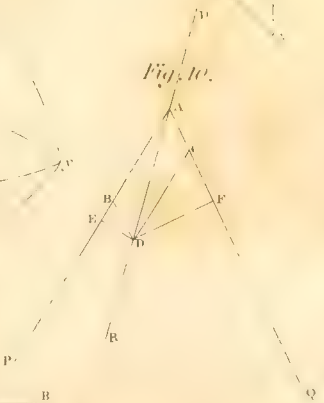

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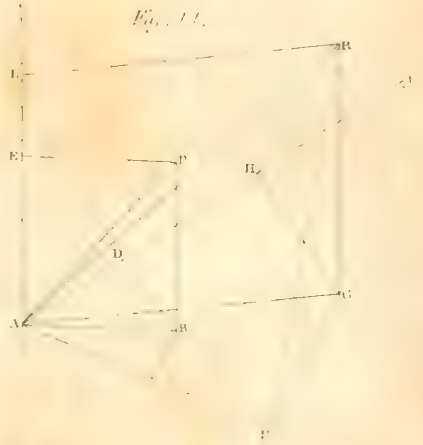

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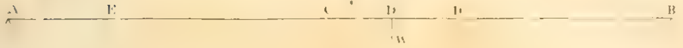

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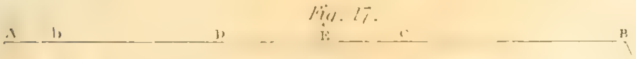

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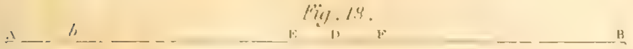

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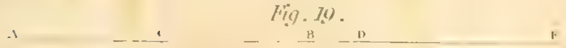

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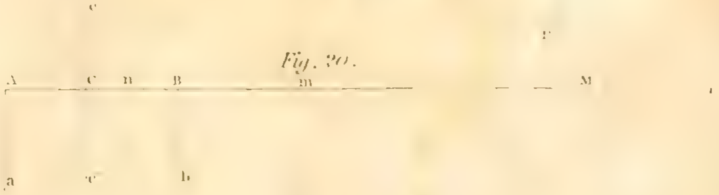

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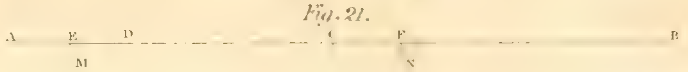
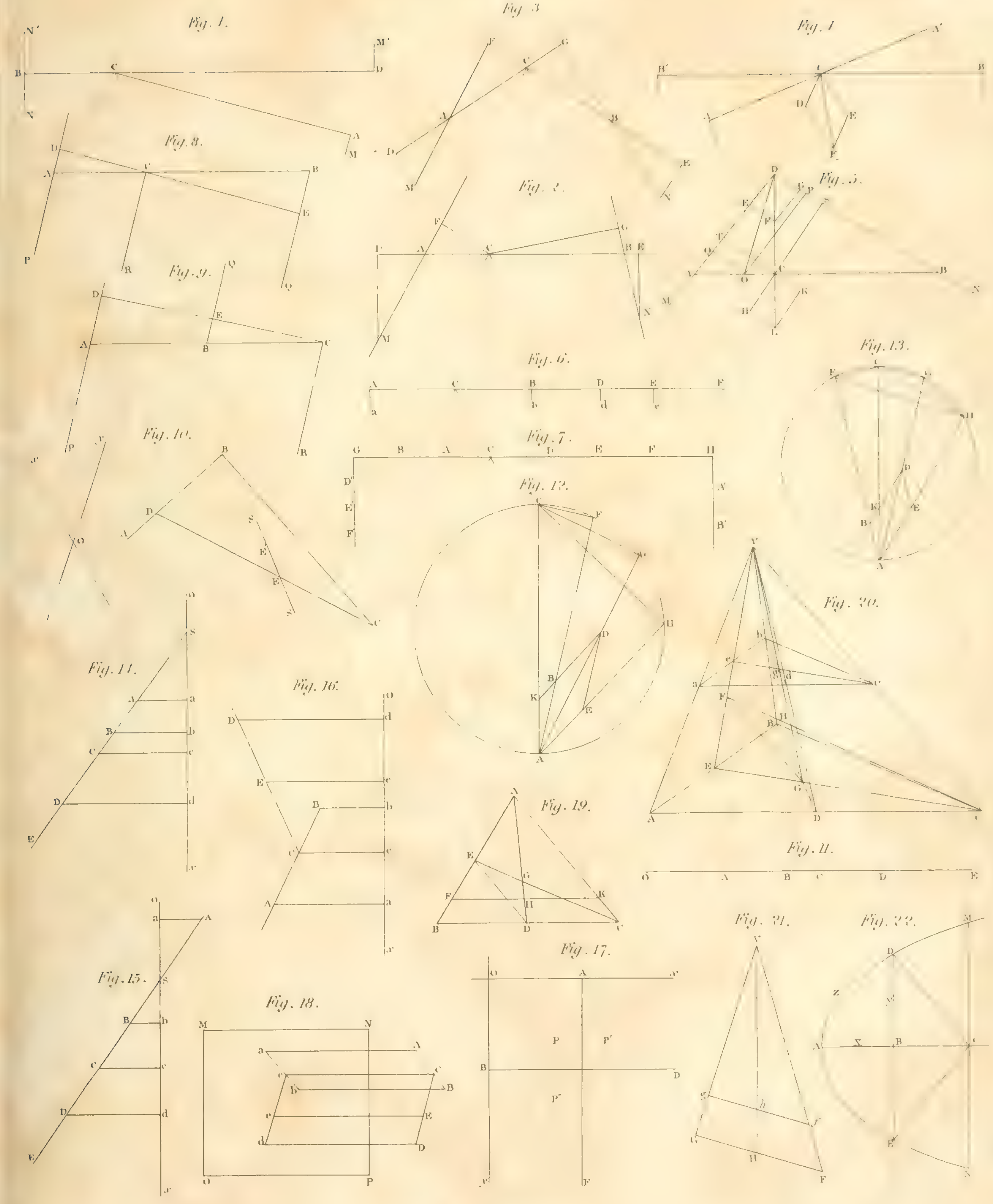


MECHANICS.

PLATE CCLX.



MECHANICS. PLATE CCCLXI.

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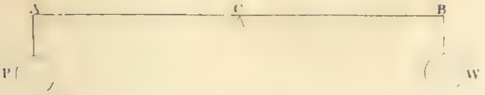

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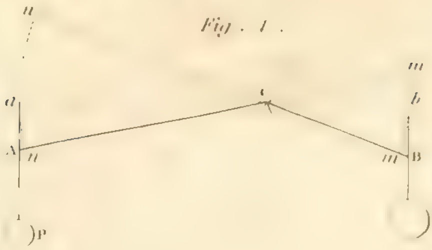

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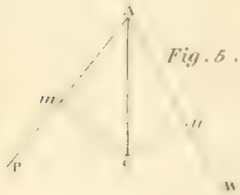

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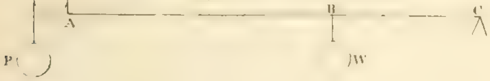

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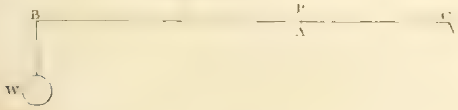

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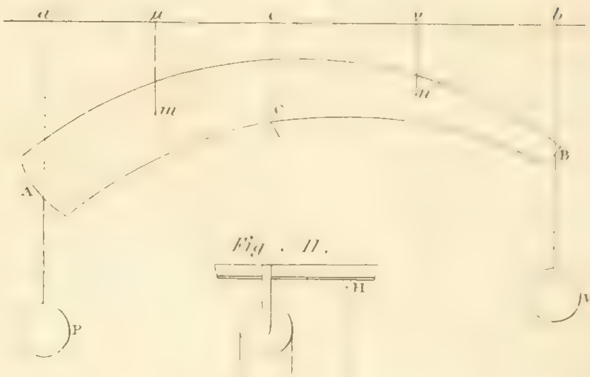

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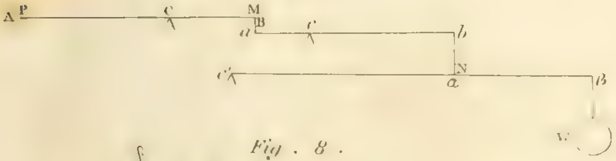

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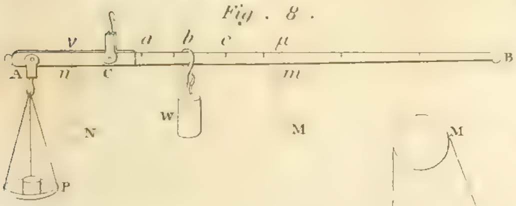

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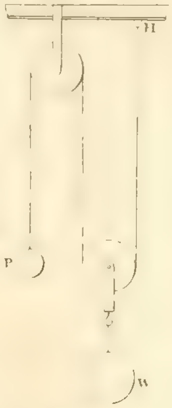

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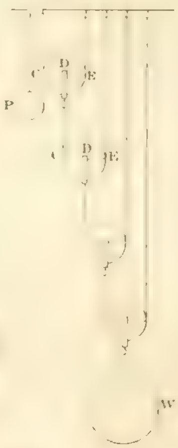

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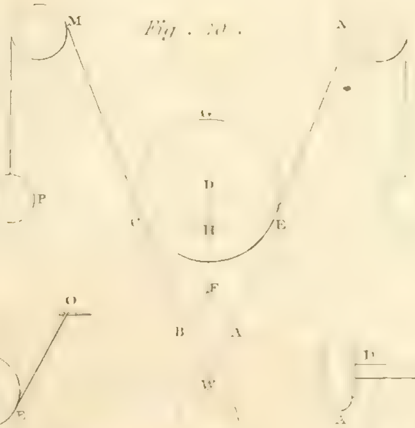

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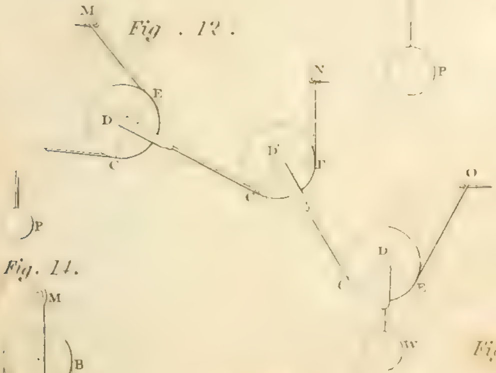

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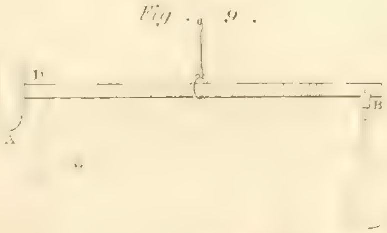

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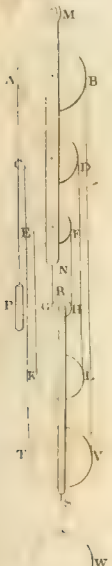

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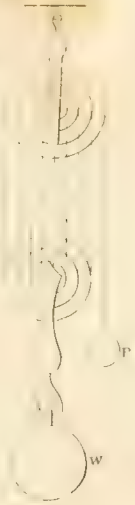

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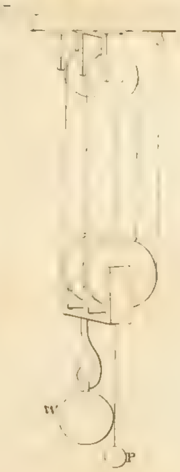

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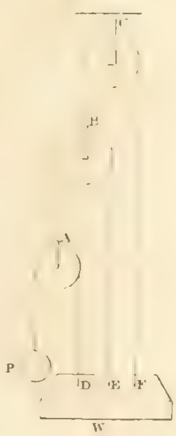

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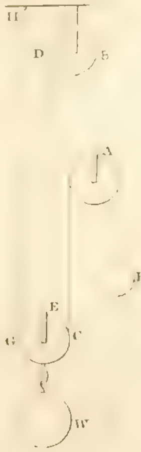

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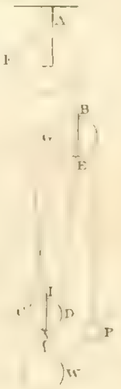

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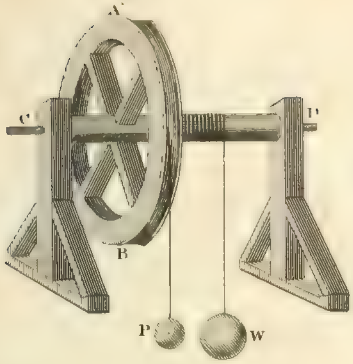

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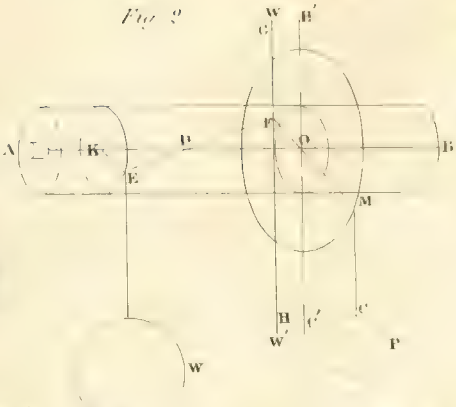

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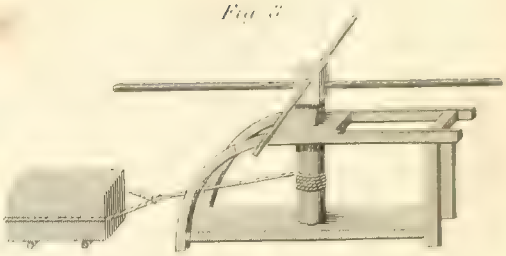

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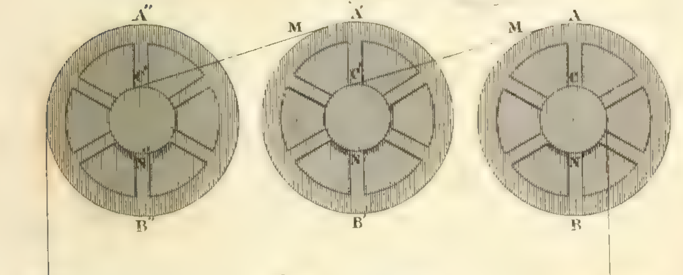

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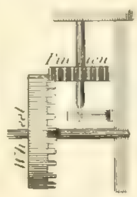

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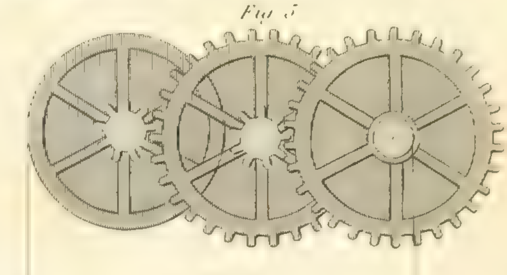

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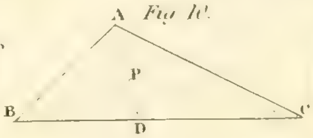

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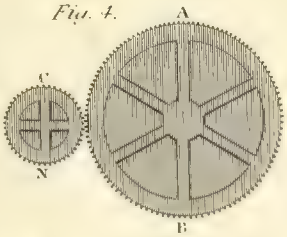

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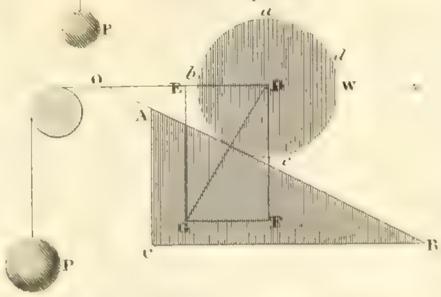

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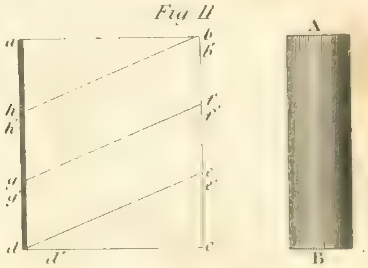

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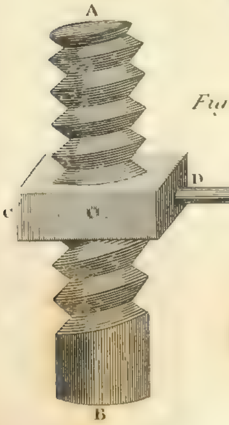

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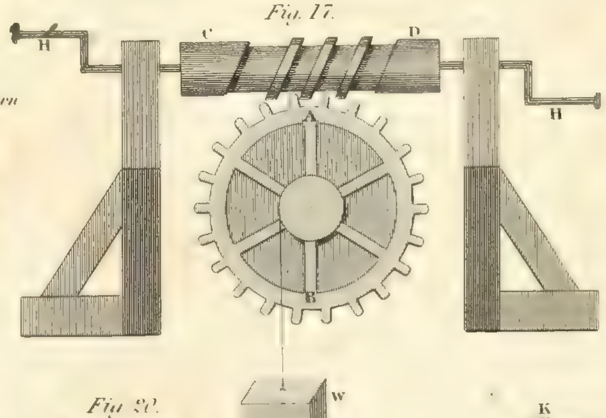

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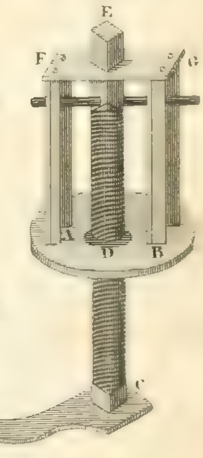

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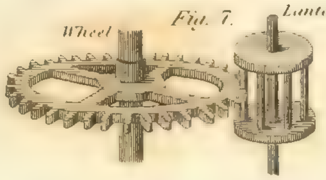

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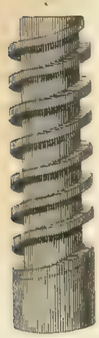

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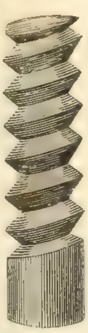

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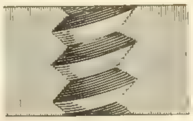

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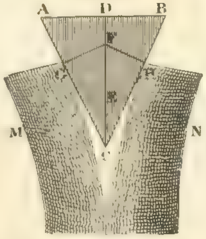

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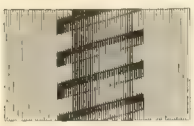

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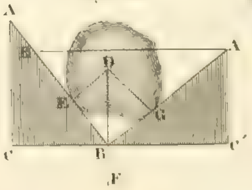
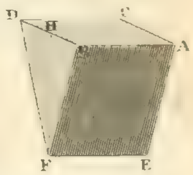


Fig 19.



MECHANICS. PLATE CCCLXIII.

Fig. 1.

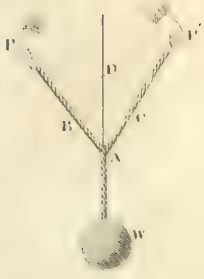


Fig. 2.

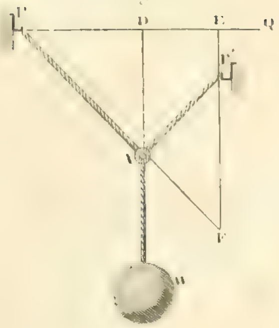
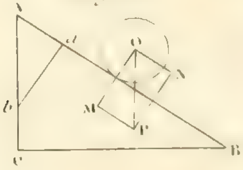


Fig. 3.



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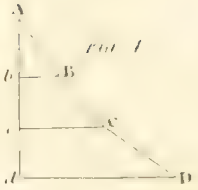

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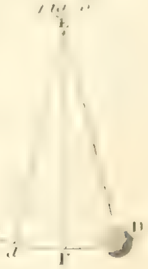

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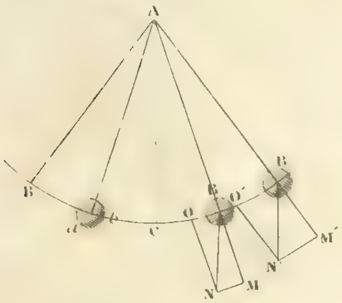

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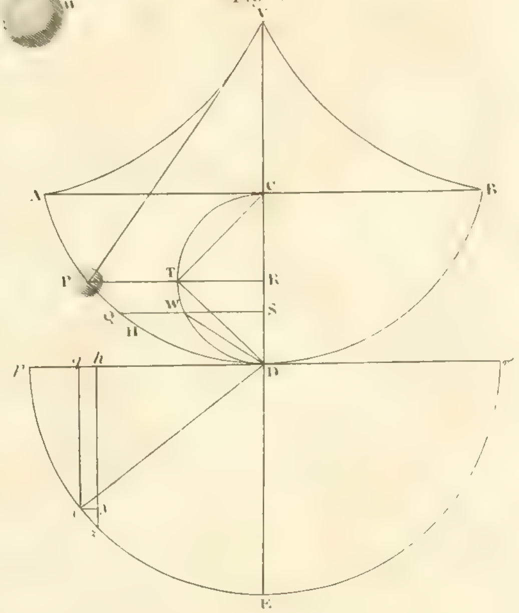

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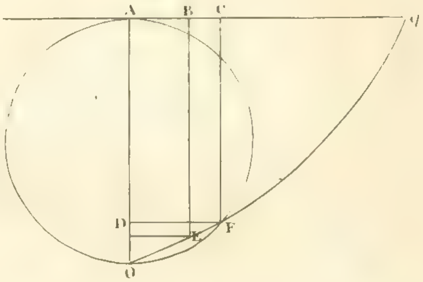

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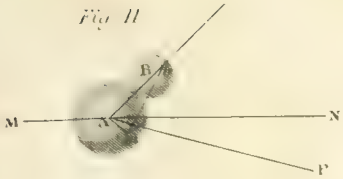

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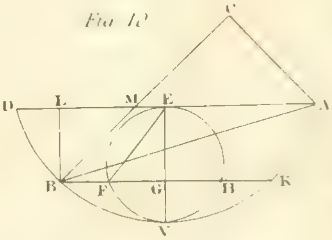

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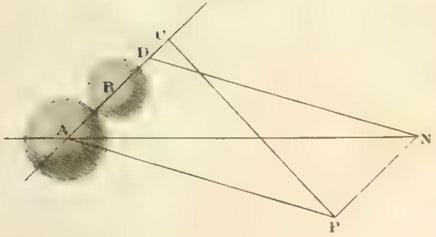
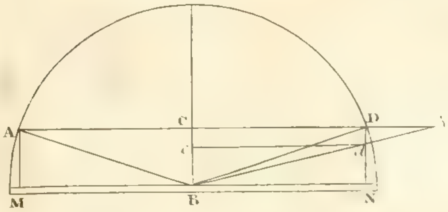


Fig. 13. p. 542. Prop 8 & 11.



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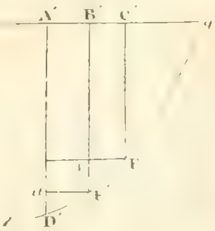

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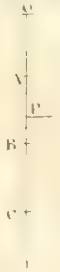

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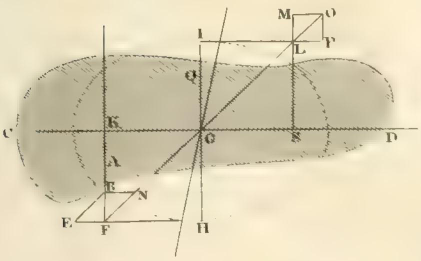
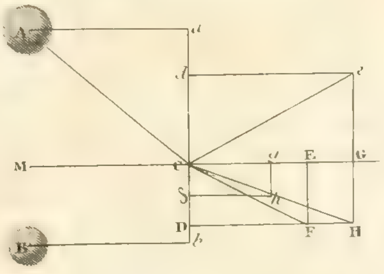


Fig. 14. p. 542. Prop. 12 & 13.



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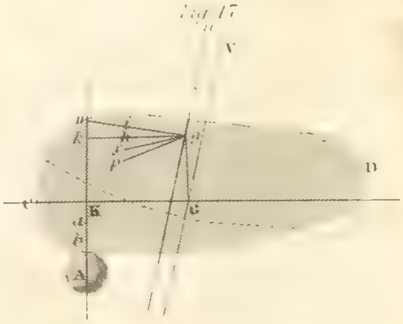
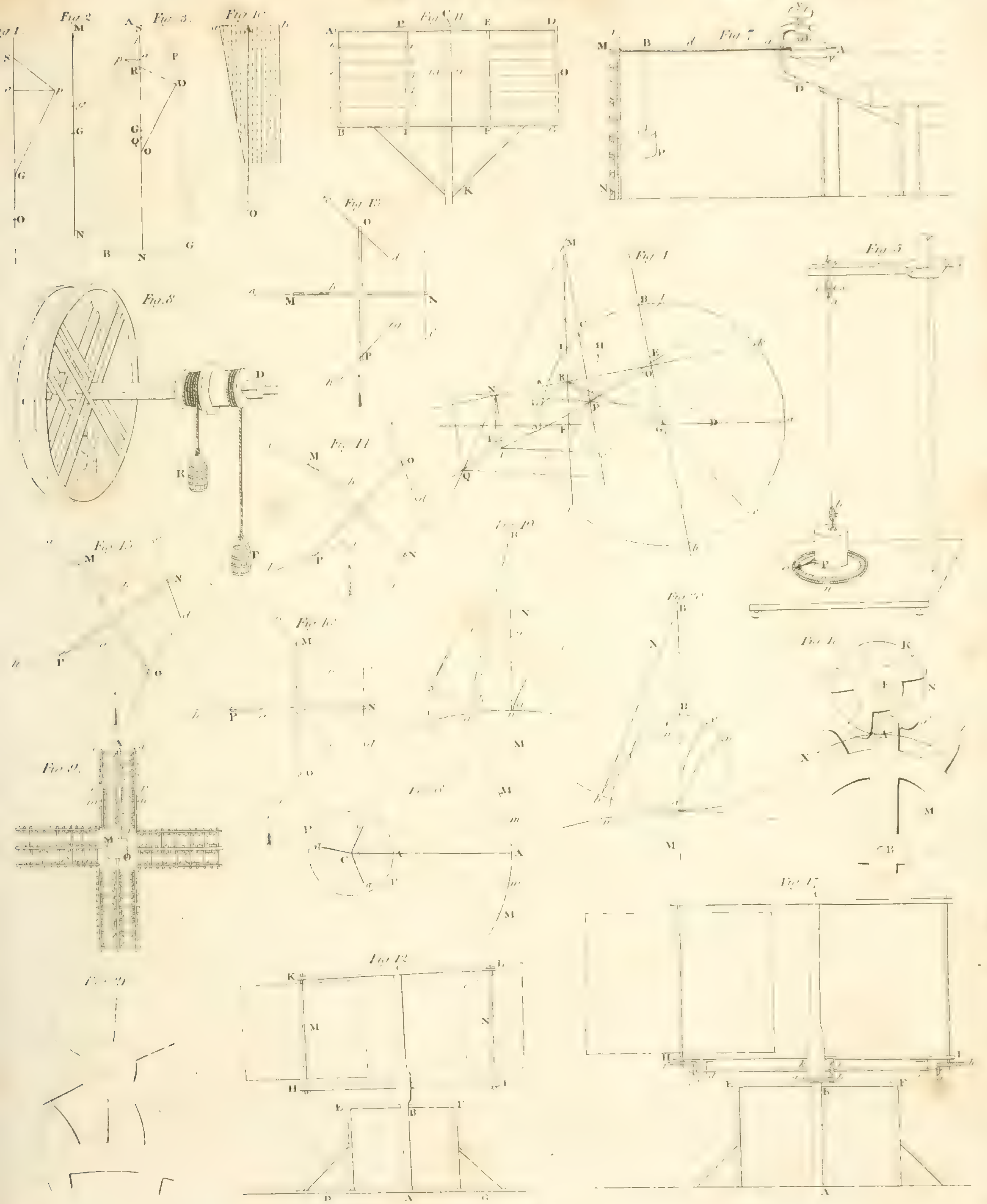
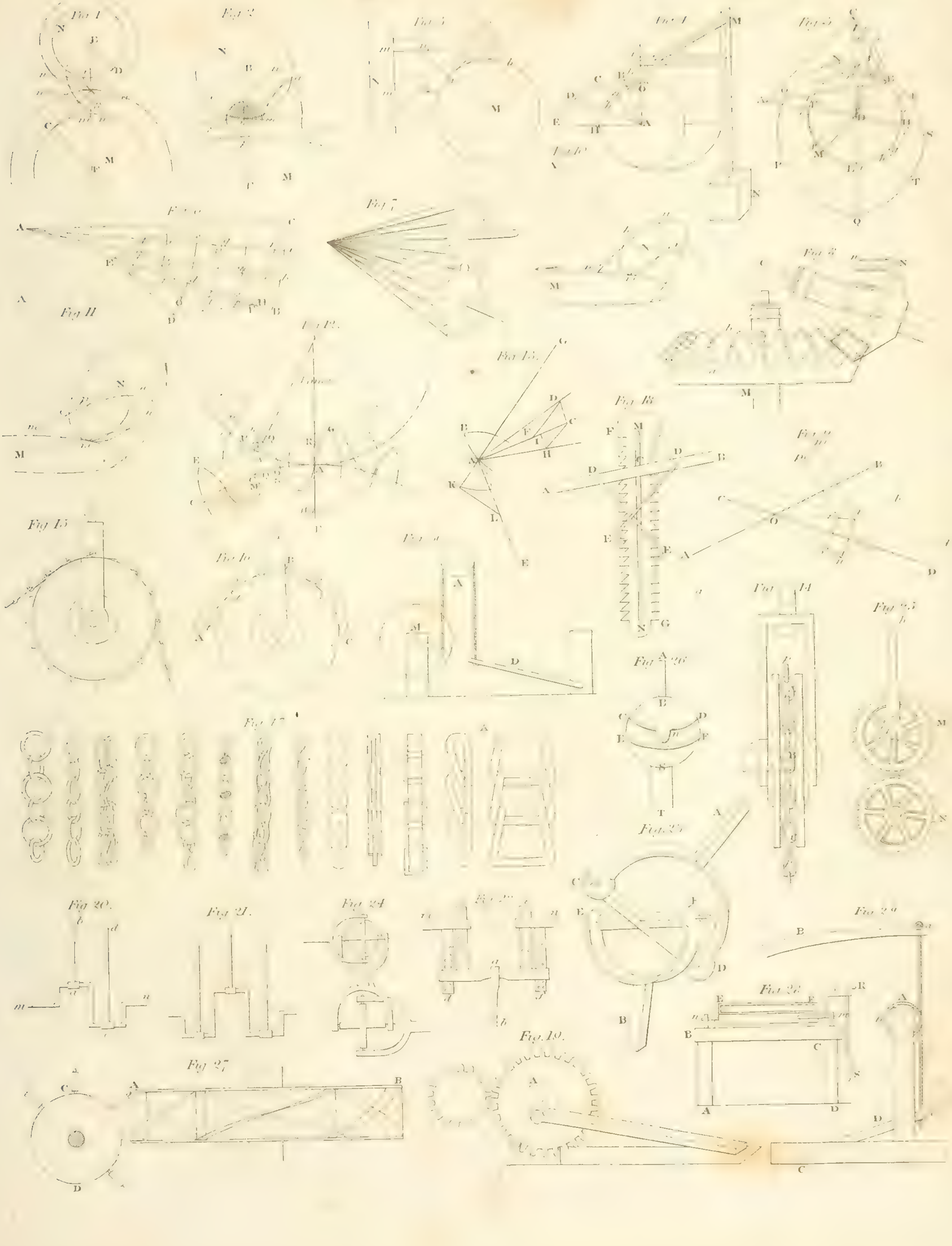


MECHANICS. PLATE CCCLXIV.



MECHANICS. *PLATE CCCLXV.*



MECHANICS.

PLATE CCCLXVI.

Fig 2

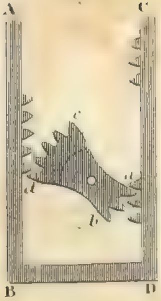


Fig 3

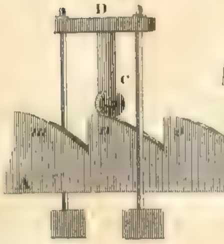


Fig 1

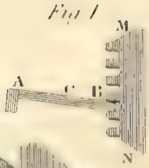


Fig 4

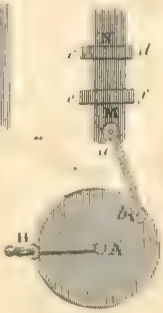


Fig 5

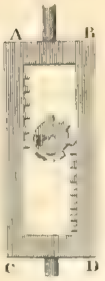


Fig 6

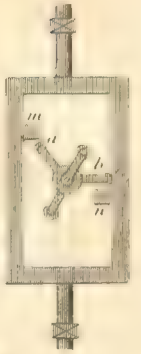


Fig 7

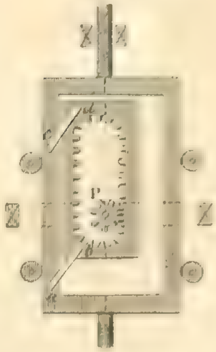
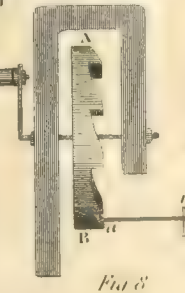


Fig 9



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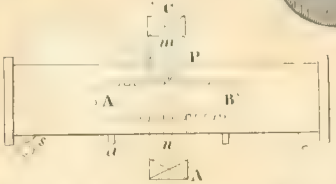

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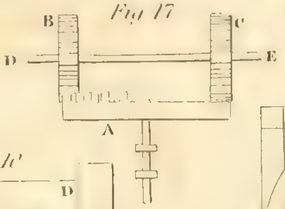

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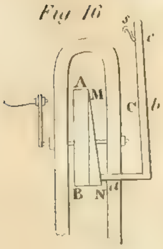

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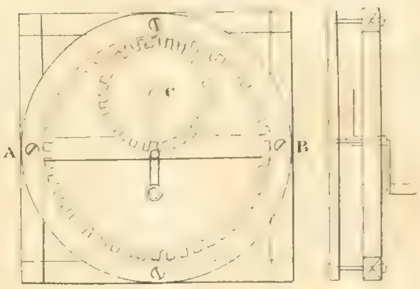
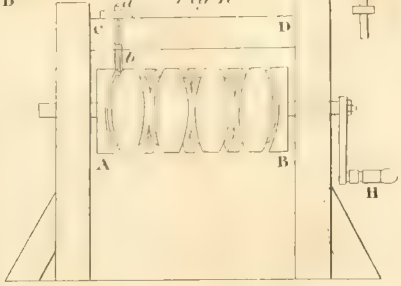


Fig 10



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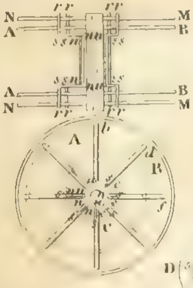
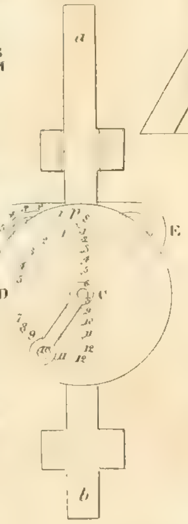


Fig 12



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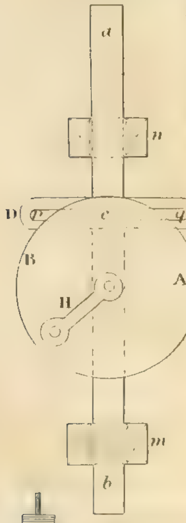
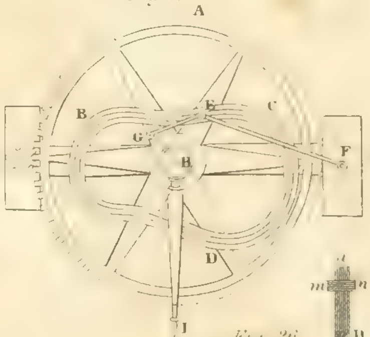


Fig 18



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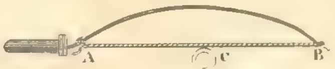

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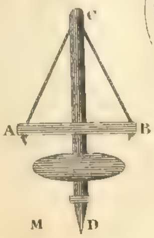


Fig 20

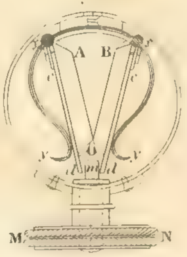


Fig 21

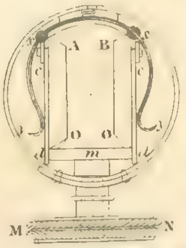
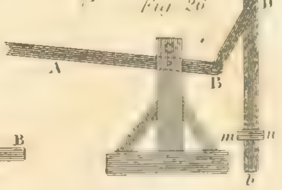


Fig 26



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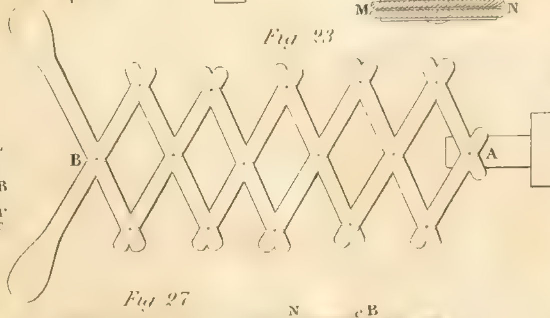


Fig 22

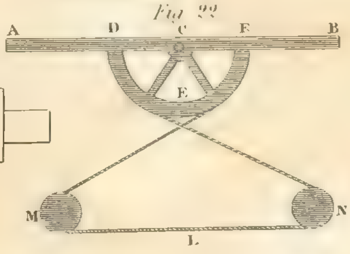


Fig 15

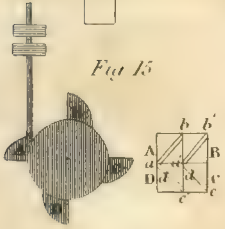


Fig 19

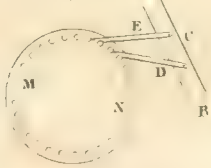
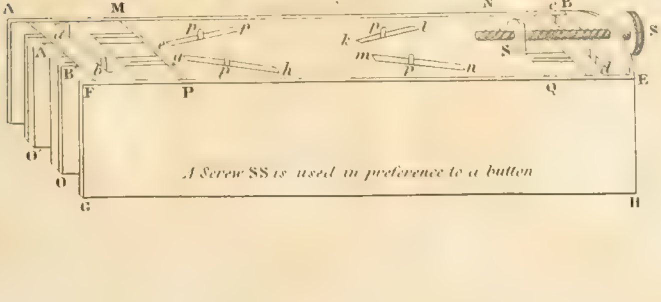
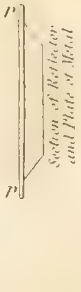


Fig 27

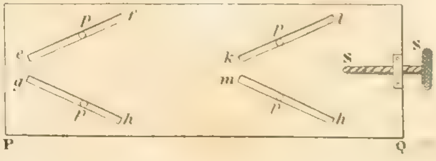


A Screw SS is used in preference to a button



Section of Reflector and Plate of Metal

Fig 28.



MECHANICS. PLATE CCCLXVII.

Fig. 1.

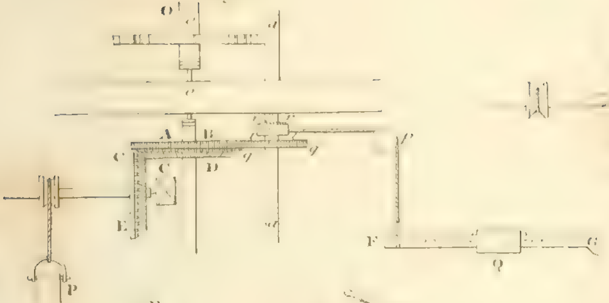


Fig. 2.

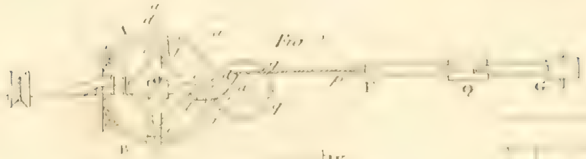


Fig. 5.

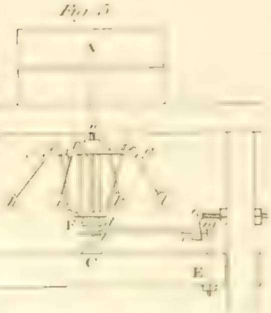


Fig. 3.

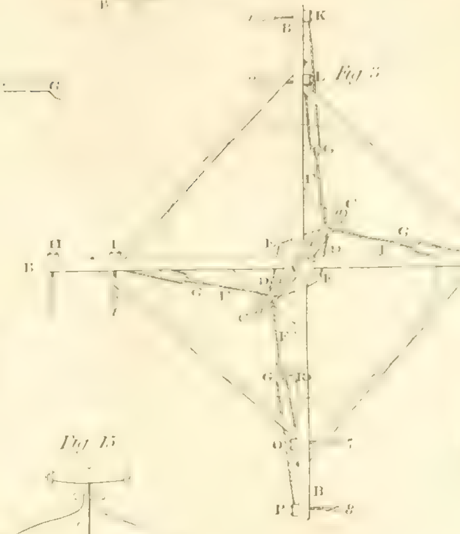


Fig. 4.

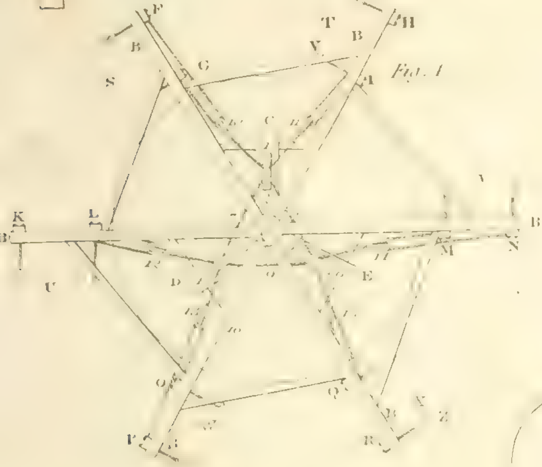


Fig. 7.

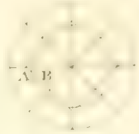


Fig. 9.

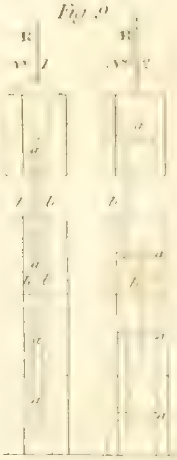
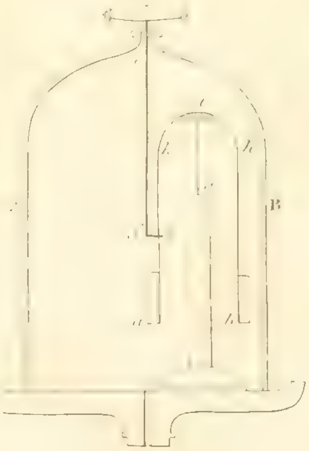


Fig. 15.



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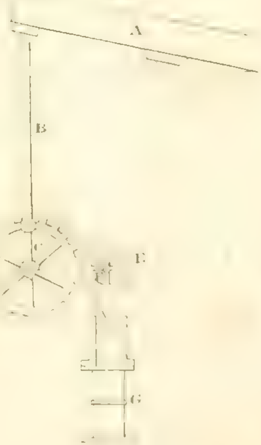


Fig. 1

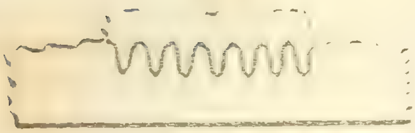


Fig. 18.

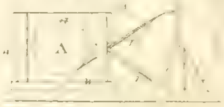


Fig. 12.

Fig. 13.

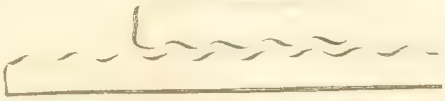


Fig. 8.

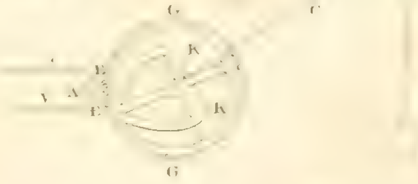


Fig. 11.

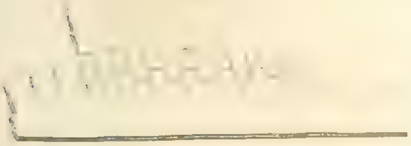


Fig. 14.

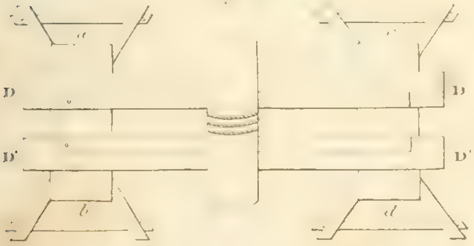
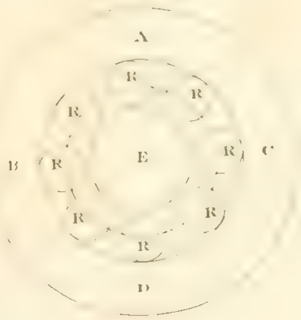


Fig. 17.



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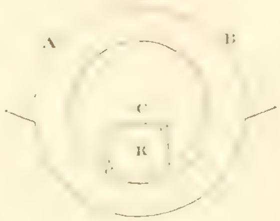
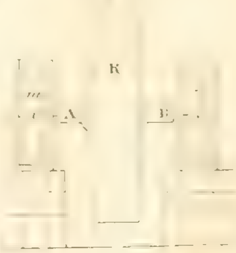


Fig. 19.



MECHANICS.

PLATE CCCLXVIII.

Fig. 2.

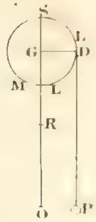


Fig. 6.

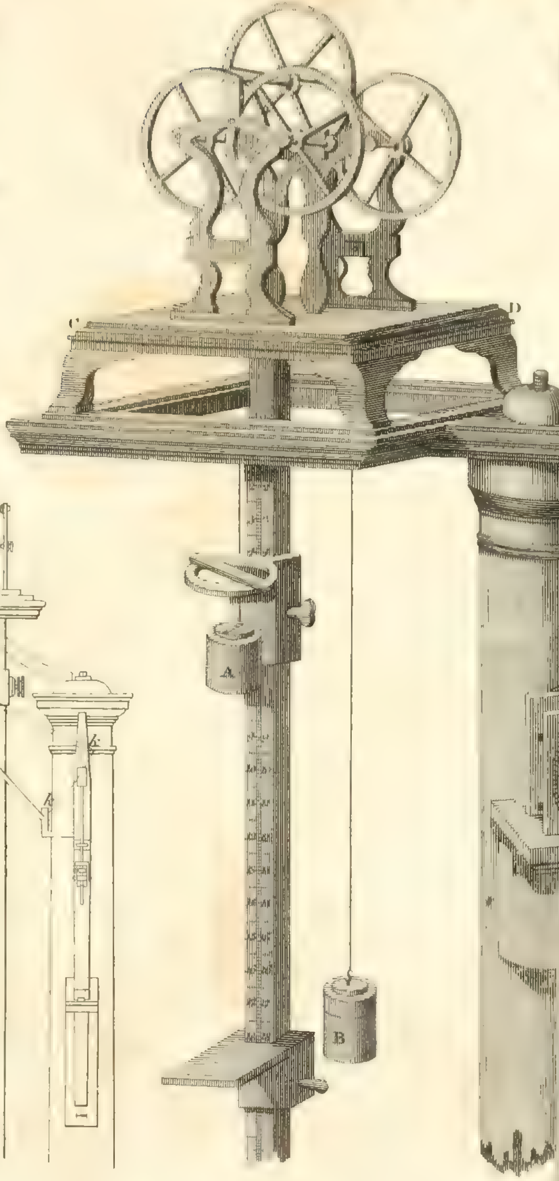


Fig. 5.

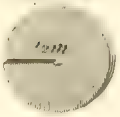


Fig. 1.

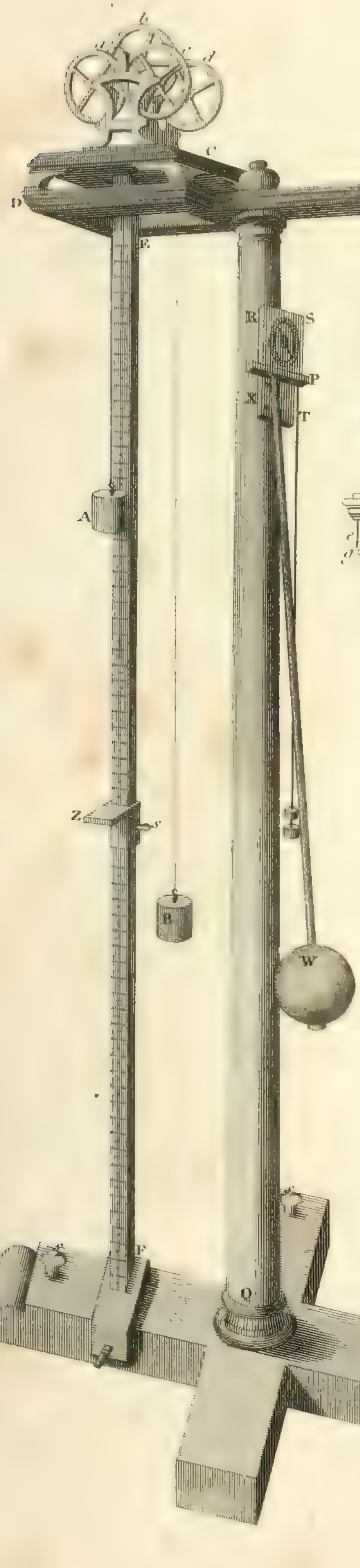


Fig. 8.

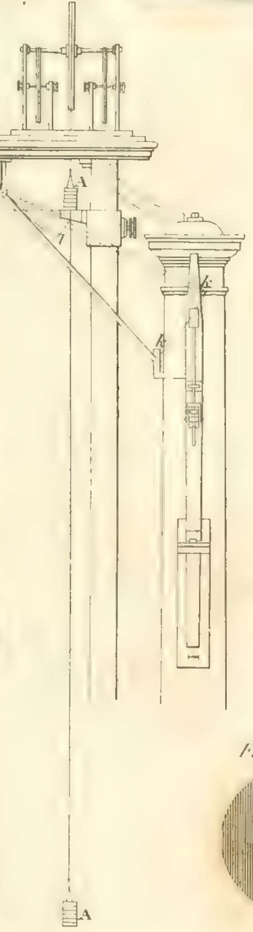
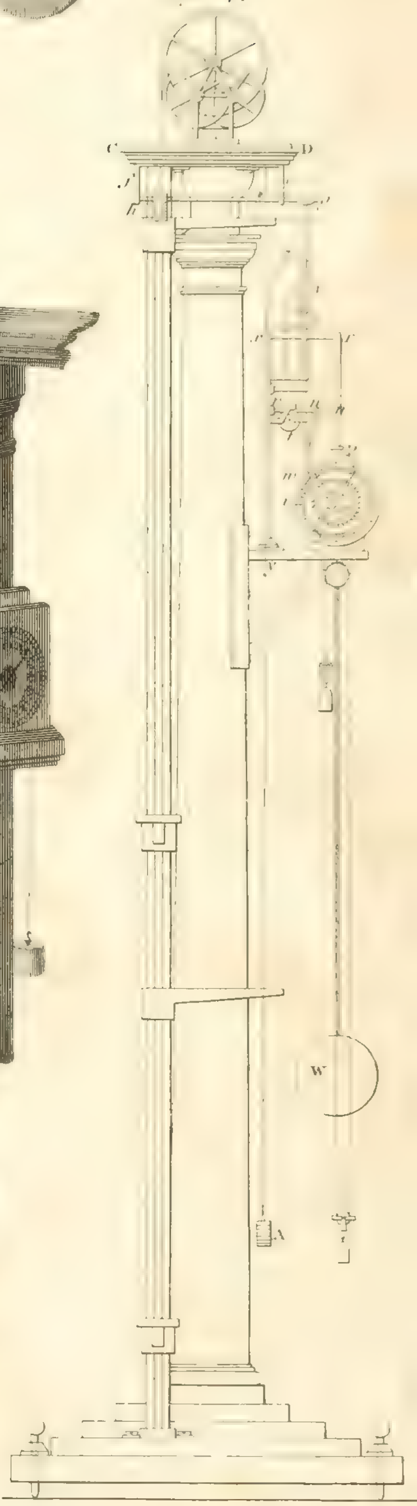


Fig. 7.



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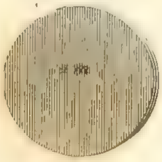

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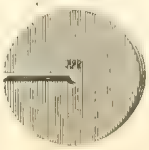

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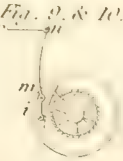
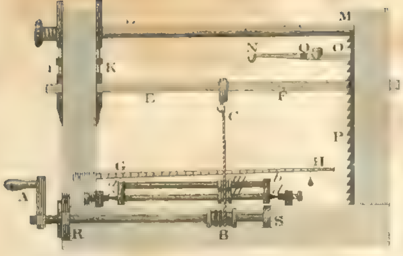


MECHANICS.

PLATE CCCLXIX.

Fig. 7



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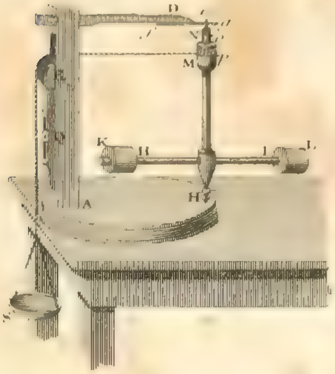

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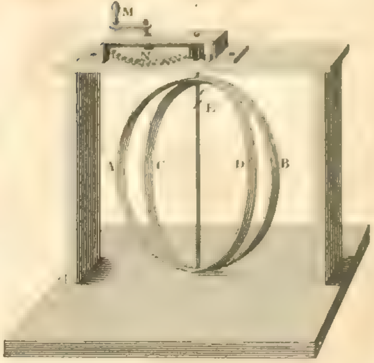

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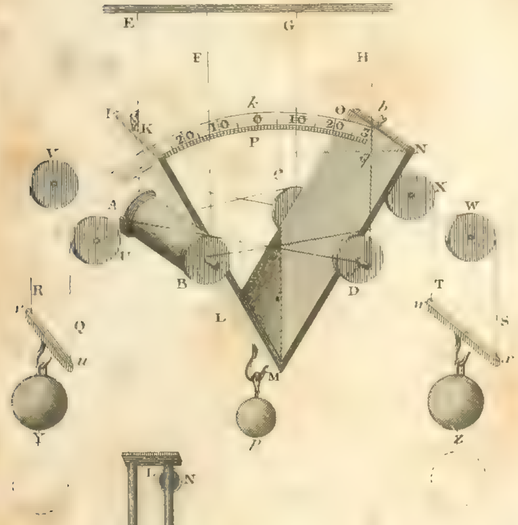

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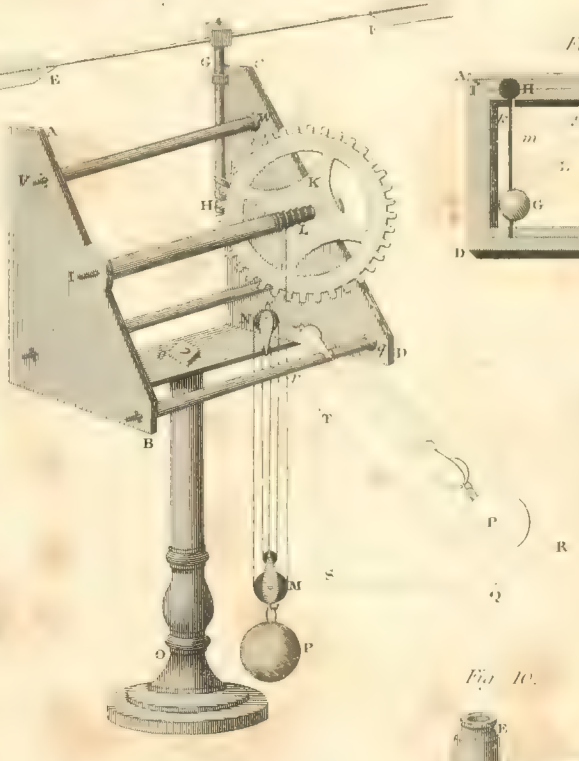

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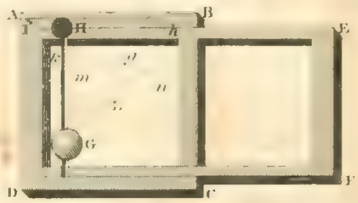

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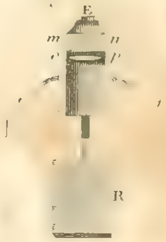

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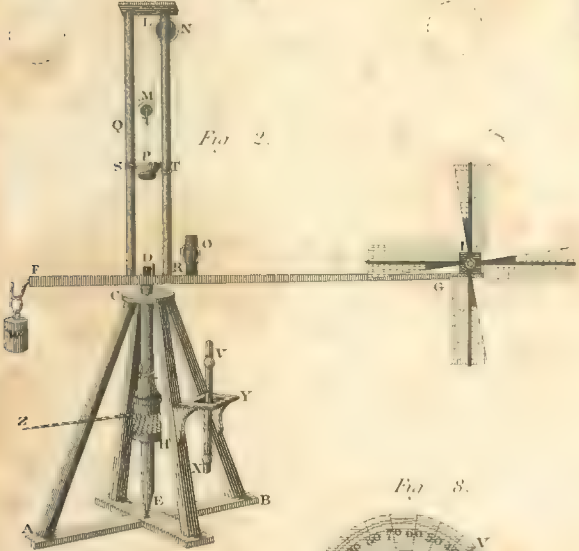

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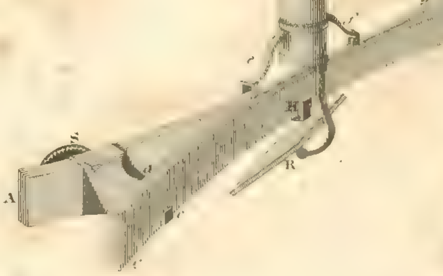
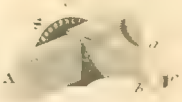


Fig. 11



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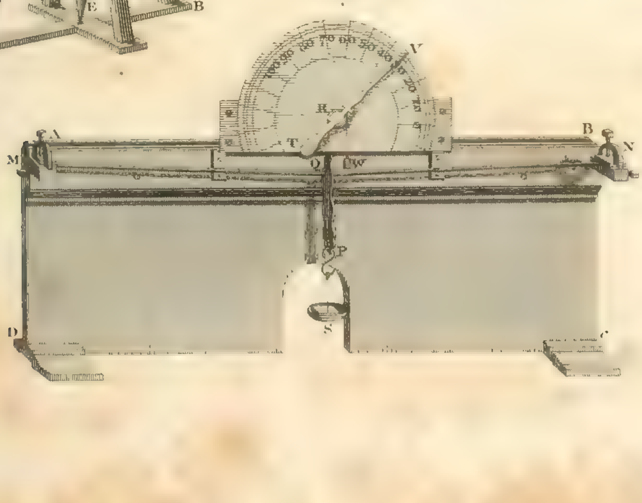

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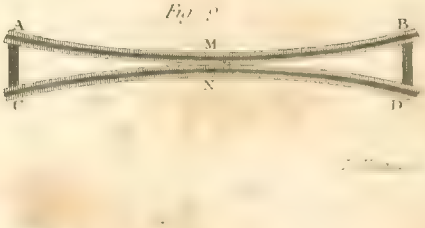

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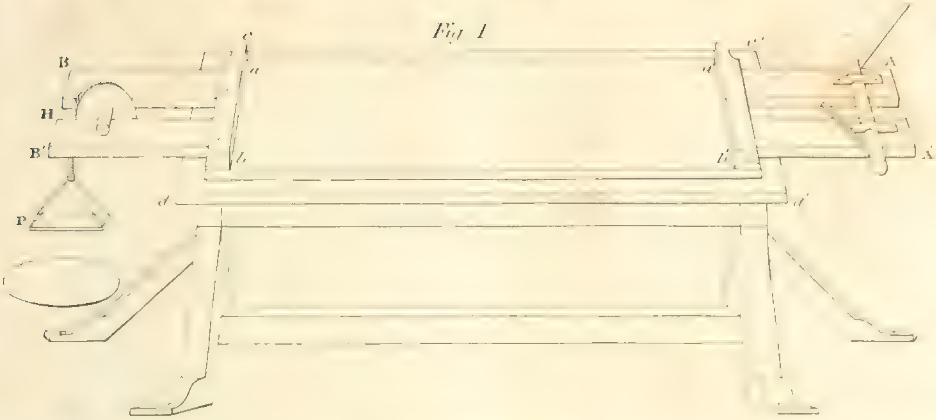

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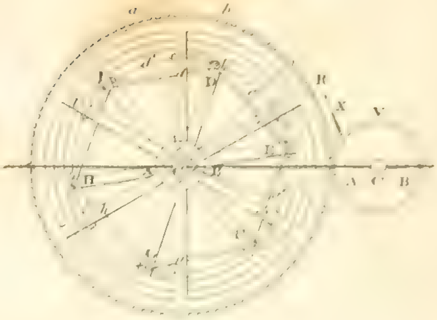

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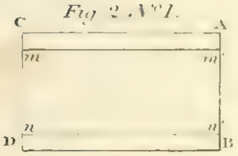

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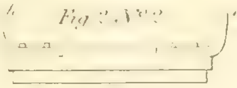

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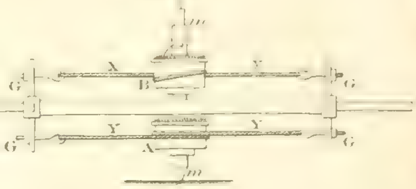

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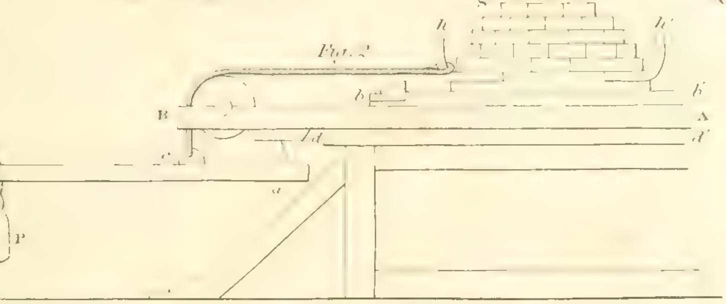

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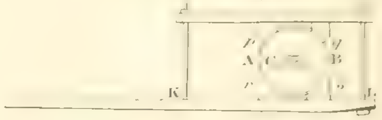

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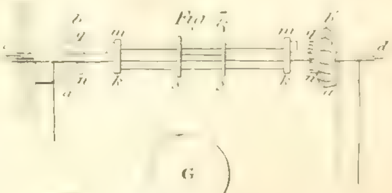

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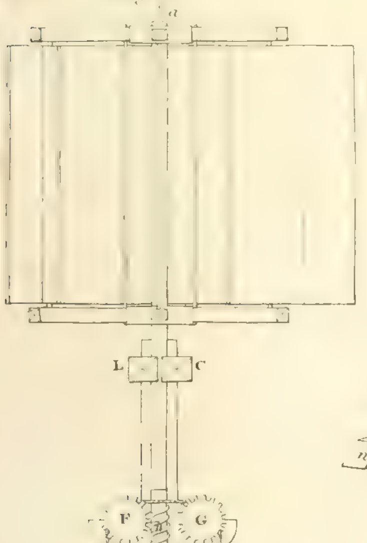

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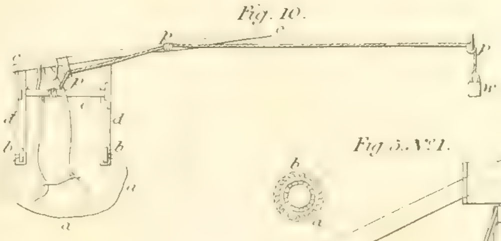

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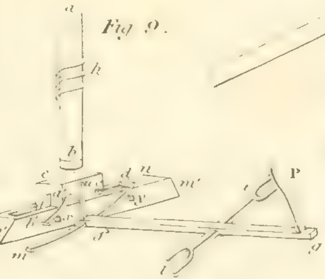

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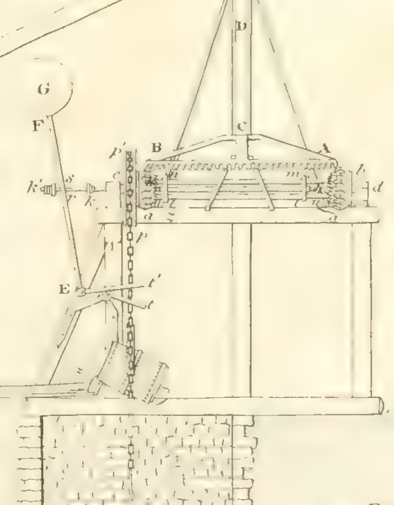

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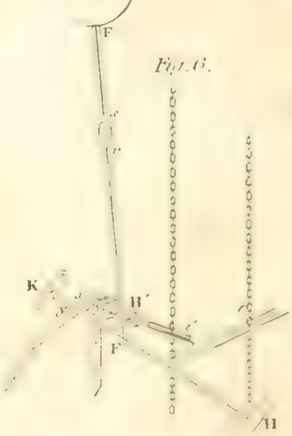

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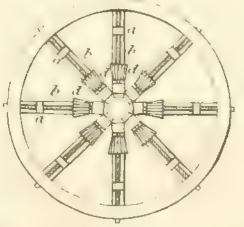

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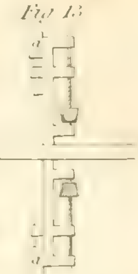

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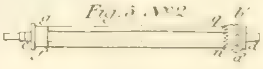

MECHANICS.

PLATE CCCLXXI.

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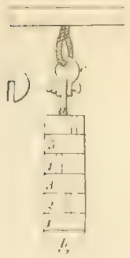

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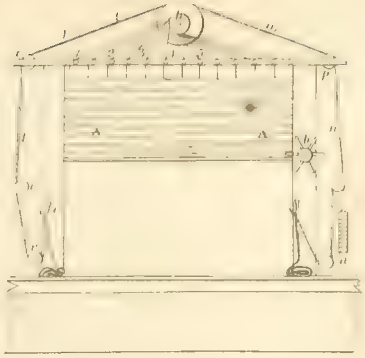

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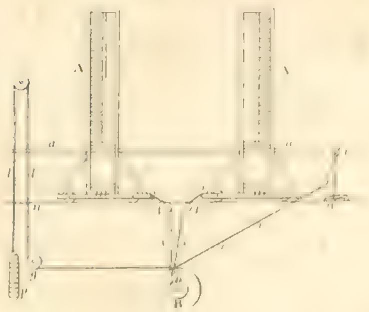

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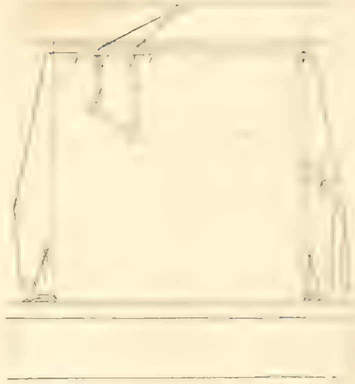

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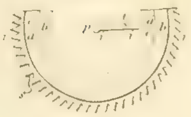

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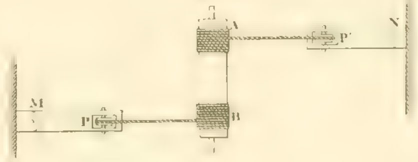

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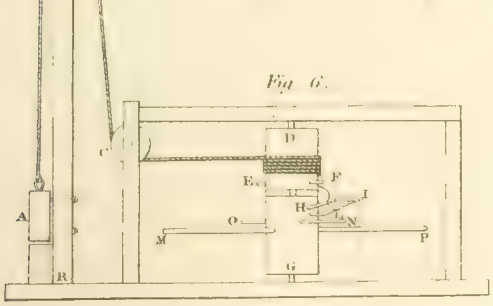

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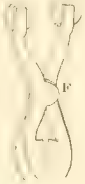

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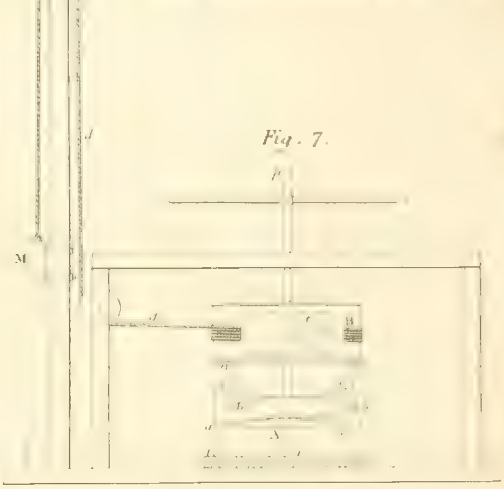

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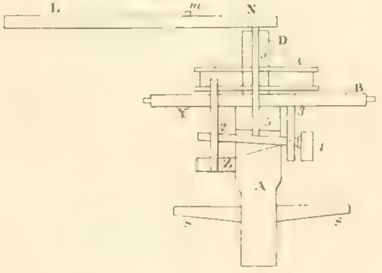

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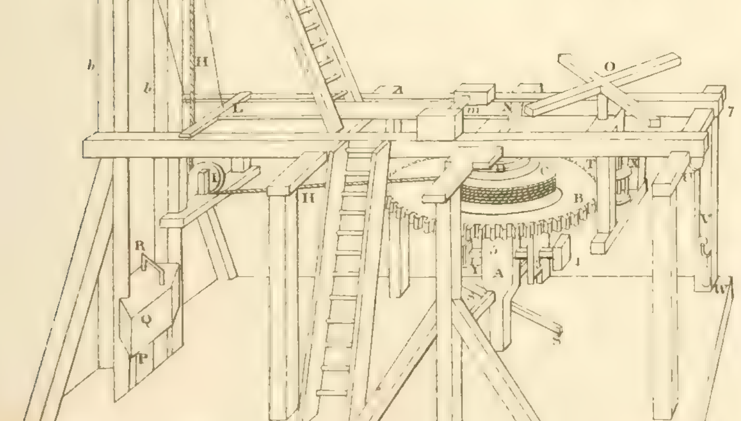

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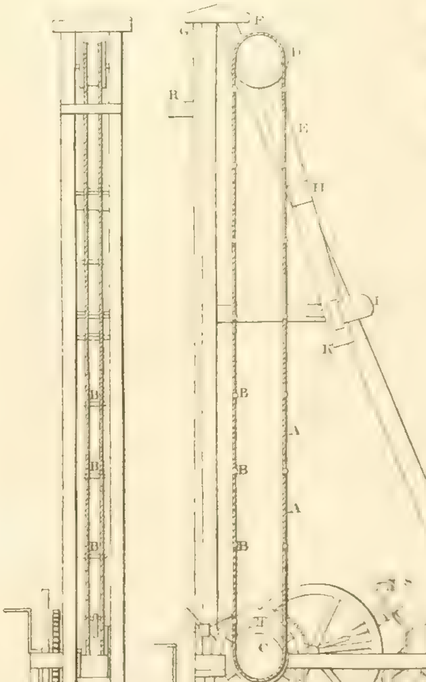

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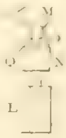

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